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The Editor's Page

TO complete the financing of U. S. Institute's warp sizing research there was needed, as of Jan. 15th, only a half-dozen more co-operators at $100 a year for two years. The $5,000 to be thus raised will qualify U. S. Institute to receive the $5,000 appropriated for this project by the Textile Foundation, dependent upon the matching of that sum dollar for dollar by U. S. Institute.

Although the Textile Foundation will allocate for this project any part of the $5,000 matched by U. S. Institute, it has been deemed unwise to start the study until the $10,000 required for two years' work is raised, and contributions have been solicited upon this basis.

IT is entirely possible that this initial venture in the co-operative financing of textile research eventually will be regarded as of far greater importance than the warp sizing project itself, irrespective of how valuable to the industry may be the results of the latter. There are numerous problems of considerable importance to various textile groups, the cost of whose investigation would be considered prohibitive by the individual mill, but whose cost distributed *pro rata* over a group would be of little moment, irrespective of results of the research.

Each co-operator in the financing of the warp sizing project gets a $10,000 study extending over two years for $200. In addition he gets the free services of U. S. Institute in promoting and organizing the project, the free services of the Research Council and also of an advisory committee made up of men having practical and technical knowledge of sizing. Incidentally this one payment gives each co-operator contributing membership in U. S. Institute and the services accruing to that class of members.

While it is true that the warp sizing study should be financed by those directly interested in sizing, the success of this initial venture in the co-operative financing of textile research is of so much greater importance that it warrants a much broader co-operation.

A Critical Study of Cotton Manufacturing Processes

The Irregularity of Card Sliver, Drawing Sliver, Roving, and Yarn for 22s, 28s, and 36s Counts Made from 1 1/16-In. Delta Cotton

By R. L. LEE, JR.*

Introduction

THIS report presents the results of a continuation of the investigation described in a previous report[1] entitled "The Irregularity of Card Sliver, Drawing Sliver, Roving, and 28s Yarn Made from 1 1/16-In. Delta Cotton." It gives further data on the variation which occurs in the uniformity of the strands used in each of the processes of manufacture of carded cotton warp yarns. The essential results of the earlier study are included in this paper so that the results of the entire investigation may be treated as a whole.

Since the results of the irregularity analyses for one yarn count could hardly be deemed to be conclusive, it was decided to carry out the procedure developed for the 28s on two other yarn counts, 22s and 36s. These two sizes were selected because they represent a substantial spread of counts from the 28s and were near, but not at, the extreme spinning range of the 1 1/16-in. Delta cotton from which they were prepared.

Each yarn was spun on a regular-draft and on a long-draft system, and a complete test and check test was made on each. This report records the results of the six tests.

All the results presented herein rest on the same basis of measurement of irregularity, namely, the weights of six-inch lengths of the strands; and on the same method of specimen selection, namely, stratified sampling. The same methods of statistical analysis are used throughout. The coefficient of variation is taken as the definite measure of irregularity. It should be noted that an important additional analysis has been developed, and is more fully described later under the topic "Analysis of Data—Lap Method."

Conclusions

Using a coefficient of variation based upon the weights of six-inch lengths, the following conclusions are presented:

* Mr. Lee as a Senior Fellow of the Textile Foundation worked under the direction of Prof. Herbert J. Ball, Head of Department of Textile Engineering, Lowell (Mass.) Textile Institute.

1. PROCESSES:

The product of the first drawing process is much less irregular than the card sliver.

The product of the second drawing process tends to be more irregular than the first drawing sliver, but not significantly so.

The product of the slubbing process is much more irregular than the second drawing sliver.

The product of the intermediate roving process tends to be less irregular than the slubber roving, but not significantly so.

The product of the fine roving process tends to be less irregular than the intermediate roving, but is not significantly so.

The product of the regular-draft spinning process is more irregular than the fine roving from which it was spun.

The product of the long-draft spinning process is much more irregular than the intermediate roving from which it was spun.

There is a decided overall increase in irregularity when the product of either spinning process is compared with the product of the card.

2. MACHINES:

Doubling decreases the irregularity of the material fed to the machine.

After eliminating the effect of doubling and leaving the effect of drafting, the machines appear in all instances to increase the irregularity of the material passing through them. The following arrangement indicates the order, arranged from worst to least, in which they stand in this respect: Spinning frame, slubbing frame, intermediate frame, second-drawing frame, fine frame, first-drawing frame.

The order of effect of the machine upon increase in irregularity closely follows that of the effective drafts of the machines.

3. OTHER RESULTS:

The difference in irregularity between yarns produced by the regular-draft and long-draft systems of manufacture is not significant except in the case of the 22s.

Procedure

The subject matter presented under the headings of Cotton, Manufacturing Conditions, Sampling Procedure, and Conditioning and Weighing of Specimens in the previous report applies to all three yarns. A brief review of the sampling procedure is included here, however. Under the following headings only exceptions to the subject matter previously reported are noted.

Organization

The drafts and hank numbers are necessarily different for different yarn counts. The organizations for the three yarn counts are shown in Table 1.

Sampling Procedure

By a method of stratified sampling, that is, the taking of several consecutive specimens from each of several spots selected at random, six-inch lengths were secured from the material being fed to or delivered from a machine. With the exception of yarn, the material was placed in a folding template 5 7/8 in. long and cut at the ends with scissors. The yarn specimens were secured by winding the yarn onto inspection boards about 8 in. long, placing a 6-in. steel template over the yarn, and cutting at the ends with a safety-razor blade.

Check measurements made upon some of the specimens showed a range of from 6 in. to 6 1/16 in. This represents an extreme variation of 1.04%.

Analysis of Data

The data of the weights of 6-inch lengths of the various strands from card sliver through the yarn have been analyzed for irregularity by either one or two methods. All the strands from each process have been analyzed by the first method, which for convenience is hereinafter referred to as the "Mass Method." Those that were doubled in being fed to a machine have also been analyzed by the second method, hereinafter designated as the "Lap Method."

Mass Method: Under this method all the specimens of material from a given process were treated as a universe or mass. It is used where it is desired to measure the variability of material delivered from a process.

Lap Method: Although the material delivered from one machine is fed to the next, the coefficient of variation of the delivered material computed by the mass method does not correctly measure the irregularity of the

TABLE 1

Organizations

Count	Machine	Draft	Doubling	Size		Twist per inch†
All						
	Picker			13	Ounces	
	Card	109.0	1	49	Grains	
	First-Drawing	6.0	6	49	Grains	
	Second-Drawing	6.0	6	49	Grains	
22s						
	Slubber	4.1	1	.69	Hank	.8
	Intermediate	4.7	2	1.62	Hank	1.4
	Fine Frame	5.6	2	4.58	Hank	2.6
	Spinning, Regular-Draft	9.8	2	22.00	Yarn	22.3
	Spinning, Long-Draft	13.6	1*	22.00	Yarn	22.3
28s						
	Slubber	4.3	1	.736	Hank	.9
	Intermediate	5.0	2	1.83	Hank	1.5
	Fine Frame	6.0	2	5.50	Hank	2.8
	Spinning, Regular-Draft	10.2	2	28.00	Yarn	25.1
	Spinning, Long-Draft	15.3	1*	28.00	Yarn	25.1
36s						
	Slubber	4.6	1	.78	Hank	.9
	Intermediate	5.3	2	2.07	Hank	1.6
	Fine Frame	6.4	2	6.58	Hank	3.1
	Spinning, Regular-Draft	11.0	2	36.00	Yarn	28.5
	Spinning, Long-Draft	17.4	1*	36.00	Yarn	28.5

* One strand of the intermediate roving was fed.

† The twist was calculated as the product of the $\sqrt{\text{Number}}$ and the standard twist multiplier.

material fed when there is a doubling of the strands. For example, where six card slivers are fed to the first drawing frame, the single specimen of entering material is composed of the six 6-in. lengths of sliver which lay beside each other when sampling occurred, and which would have gone into the machine together in the form of a sheet or lap. In these cases the weight data must be assembled in a different manner before analysis, and the resulting procedure has been designated as the "Lap Method." This has been used in stating the irregularity of the material fed to all machines except the slubber and long-draft spinning frame, and yields some information on the effect of doubling. It is to be noted that with a doubling of

six, an original number of 240 specimens is reduced to 40; with a doubling of two, there are 120 resultant specimens.

In analyzing data by either method, the weights of the 6-in. units were arranged in a frequency distribution and computations made of the mean, standard deviation of the mean, together with the coefficient of variation and its standard error. The results are shown, with other data, in Tables 2 to 7 inclusive.

TABLE 2

Summary of analyses of test for irregularity—22s yarn

Line	Material	Method of Analysis *	No. of Specimens	Class Interval		Mean Weight Grams	Standard Deviation Grams	Coefficient of Variation ± S. E. Per Cent
				Unit Grams	No.			
	SLIVER †							
1	Card	M	480	0.01	21	0.5599	0.0363	6.48 ±0.21
2		L	80	.03	14	3.3563	.0991	2.95 ± .24
3	First Drawing	M	240	.01	12	.5479	.0221	4.03 ± .18
4		L	40	.02	10	3.2855	.0499	1.52 ± .17
5	Second Drawing	M	240	.01	14	.5180	.0244	4.71 ± .22
6	Second Drawing fed to slubber	M	240	.01	16	.5130	.0242	4.72 ± .22
	REGULAR-DRAFT ORGANIZATION							
	ROVING							
7	Slubber	M	240	.005	12	.1354	.0106	7.83 ± .36
8		L	120	.005	16	.2715	.0147	5.41 ± .35
9	Intermediate	M	240	.001	24	.0562	.0042	7.47 ± .34
10		L	120	.002	15	.1121	.0058	5.17 ± .33
11	Fine Frame	M	240	.0005	16	.02004	.00133	6.64 ± .30
12		L	120	.0005	22	.04009	.00197	4.91 ± .32
	YARN							
13	Regular-draft	M	240	.0002	11	.00431	.00040	9.28 ± .43
	LONG-DRAFT ORGANIZATION							
	ROVING							
14	Slubber	M	240	.005	12	.1341	.0115	8.57 ± .39
15		L	120	.005	17	.2689	.0161	5.99 ± .39
16	Intermediate	M	240	.001	23	.0559	.0042	7.51 ± .35
	YARN							
17	Long-draft	M	240	.0002	16	.00417	.00054	12.95 ± .60

* M indicates the analysis by the mass method.

L indicates the analysis by the lap method.

† The sliver was common to both the regular-draft and the long-draft organizations.

TABLE 3

Summary of analyses of check test for irregularity—22s yarn

Line	Material	Method of Analysis *	No. of Specimens	Class Interval		Mean Weight Grams	Standard Deviation Grams	Coefficient of Variation ± S. E. Per Cent
				Unit Grams	No.			
	SLIVER †							
1	Card	M	480	0.01	23	.5527	0.0369	6.68±0.22
2		L	80	.03	15	3.3158	.1061	3.20± .25
3	First Drawing	M	240	.01	13	.5413	.0214	3.95± .18
4		L	40	.02	10	3.2460	.0418	1.29± .15
5	Second Drawing	M	240	.01	18	.5326	.0298	5.60± .26
6	Second Drawing fed to slubber	M	240	.01	20	.5276	.0295	5.59± .26
	REGULAR-DRAFT ORGANIZATION							
	ROVING							
7	Slubber	M	240	.005	15	.1339	.0127	9.48± .44
8		L	120	.005	20	.2682	.0183	6.82± .44
9	Intermediate	M	240	.001	24	.0561	.0046	8.20± .38
10		L	120	.002	18	.1121	.0063	5.61± .36
11	Fine Frame	M	240	.0005	18	.02047	.00153	7.47± .34
12		L	120	.0005	19	.04103	.00194	4.73± .31
	YARN							
13	Regular-draft	M	240	.0002	12	.00456	.00039	8.55± .39
	LONG-DRAFT ORGANIZATION							
	ROVING							
14	Slubber	M	240	.005	15	.1313	.0130	9.90± .46
15		L	120	.005	16	.2629	.0165	6.28± .41
16	Intermediate	M	240	.001	21	.0555	.0040	7.21± .33
	YARN							
17	Long-draft	M	240	.0002	14	.00457	.00056	12.25± .57

* M indicates the analysis by the mass method.

L indicates the analysis by the lap method.

† The sliver was common to both the regular-draft and the long-draft organizations.

TABLE 4

Summary of analyses of test for irregularity—28s yarn

Line	Material	Method of Analysis *	No. of Specimens	Class Interval		Mean Weight Grams	Standard Deviation Grams	Coefficient of Variation ± S. E. Per Cent
				Unit Grams	No.			
	SLIVER †							
1	Card	M	480	0.01	24	0.5584	0.0436	7.81 ±0.25
2		L	80	.03	15	3.3510	.0998	2.98 ± .24
3	First Drawing	M	240	.01	13	.5320	.0239	4.49 ± .21
4		L	40	.02	10	3.1905	.0472	1.48 ± .17
5	Second Drawing	M	240	.01	16	.5532	.0263	4.76 ± .22
6	Second Drawing fed to slubber	M	240	.01	15	.5555	.0255	4.59 ± .21
	REGULAR-DRAFT ORGANIZATION ROVING							
7	Slubber	M	240	.005	15	.1273	.0119	9.38 ± .43
8		L	120	.005	18	.2553	.0175	6.85 ± .45
9	Intermediate	M	240	.001	22	.0519	.0040	7.71 ± .35
10		L	120	.002	15	.1034	.0057	5.51 ± .36
11	Fine Frame	M	240	.0005	16	.01643	.00125	7.61 ± .35
12		L	120	.001	12	.03238	.00180	5.56 ± .36
	YARN							
13	Regular-draft	M	240	.0001	15	.00306	.00026	8.50 ± .39
	LONG-DRAFT ORGANIZATION ROVING							
14	Slubber	M	240	.005	13	.1231	.0091	7.39 ± .34
15		L	120	.005	14	.2469	.0132	5.35 ± .35
16	Intermediate	M	240	.001	25	.0500	.0036	7.20 ± .33
	YARN							
17	Long-draft	M	240	.0001	19	.00313	.00033	10.54 ± .49

* M indicates the analysis by the mass method.
L indicates the analysis by the lap method.

† The sliver was common to both the regular-draft and the long-draft organizations.

TABLE 5

Summary of analyses of check test for irregularity—28s yarn

Line	Material	Method of Analysis *	No. of Specimens	Class Interval		Mean Weight Grams	Standard Deviation Grams	Coefficient of Variation ± S. E. Per Cent
				Unit Grams	No.			
	SLIVER †							
1	Card	M	480	0.02	22	0.6014	0.0634	10.54±0.34
2		L	80	.03	23	3.6094	.1684	4.67± .37
3	First Drawing	M	240	.01	14	.5911	.0261	4.42± .20
4		L	40	.02	17	3.5420	.0726	2.05± .23
5	Second Drawing	M	240	.01	14	.5580	.0245	4.39± .20
6	Second Drawing fed to slubber	M	240	.01	13	.5520	.0220	3.99± .18
	REGULAR-DRAFT ORGANIZATION							
	ROVING							
7	Slubber	M	240	.005	10	.1267	.0090	7.10± .33
8		L	120	.005	14	.2540	.0132	5.20± .34
9	Intermediate	M	240	.001	20	.0505	.0034	6.73± .31
10		L	120	.002	11	.1010	.0046	4.55± .30
11	Fine Frame	M	240	.0005	13	.01529	.00111	7.26± .33
12		L	120	.001	9	.03017	.00184	6.10± .40
	YARN							
13	Regular-draft	M	240	.0001	20	.00323	.00043	13.31± .62
	LONG-DRAFT ORGANIZATION							
	ROVING							
14	Slubber	M	240	.005	12	.1256	.0095	7.56± .35
15		L	120	.005	18	.2517	.0143	5.68± .37
16	Intermediate	M	240	.001	20	.0500	.0038	7.60± .35
	YARN							
17	Long-draft	M	240	.0001	19	.00355	.00038	10.70± .50

* M indicates the analysis by the mass method.
L indicates the analysis by the lap method.

† The sliver was common to both the regular-draft and the long-draft organizations.

TABLE 6

Summary of analyses of test for irregularity—36s yarn

Line	Material	Method of Analysis *	No. of Specimens	Class Interval		Mean Weight Grams	Standard Deviation Grams	Coefficient of Variation ± S. E. Per Cent
				Unit Grams	No.			
	SLIVER †							
1	Card ‡	M	480	0.01	21	0.5599	0.0363	6.48 ±0.21
2		L	80	.03	14	3.3563	.0991	2.95 ± .24
3	First Drawing ‡	M	240	.01	12	.5479	.0221	4.03 ± .18
4		L	40	.02	10	3.2855	.0499	1.52 ± .17
5	Second Drawing ‡	M	240	.01	14	.5180	.0244	4.71 ± .22
6	Second Drawing fed to slubber	M	240	.01	17	.5176	.0274	5.29 ± .24
	REGULAR-DRAFT ORGANIZATION							
	ROVING							
7	Slubber	M	240	.005	12	.1144	.0097	8.48 ± .39
8		L	120	.005	14	.2272	.0132	5.81 ± .38
9	Intermediate	M	240	.001	21	.0443	.0035	7.90 ± .36
10		L	120	.002	16	.0882	.0053	6.01 ± .39
11	Fine Frame	M	240	.0005	11	.01422	.00092	6.47 ± .30
12		L	120	.0005	13	.02845	.00124	4.35 ± .28
	YARN							
13	Regular-draft	M	240	.0001	17	.00281	.00031	11.03 ± .51
	LONG-DRAFT ORGANIZATION							
	ROVING							
14	Slubber	M	240	.005	11	.1124	.0100	8.90 ± .41
15		L	120	.005	14	.2252	.0140	6.22 ± .40
16	Intermediate	M	240	.001	20	.0456	.0035	7.68 ± .35
	YARN							
17	Long-draft	M	240	.0001	15	.00270	.00027	10.00 ± .46

* M indicates the analysis by the mass method.

L indicates the analysis by the lap method.

† The sliver was common to both the regular-draft and the long-draft organizations.

‡ The card, first drawing, and second drawing values are the same as for 22s yarn test.

TABLE 7

Summary of analyses of check test for irregularity—36s yarn

Line	Material	Method of Analysis *	No. of Specimens	Class Interval		Mean Weight Grams	Standard Deviation Grams	Coefficient of Variation ± S. E. Per Cent
				Unit Grams	No.			
	SLIVER †							
1	Card ‡	M	480	0.01	23	0.5527	0.0369	6.68 ±0.22
2		L	80	.03	15	3.3158	.1061	3.20 ± .25
3	First Drawing ‡	M	240	.01	13	.5413	.0214	3.95 ± .18
4		L	40	.02	10	3.2460	.0418	1.29 ± .15
5	Second Drawing ‡	M	240	.01	18	.5326	.0298	5.60 ± .26
6	Second Drawing fed to slubber	M	240	.01	21	.5326	.0300	5.63 ± .26
	REGULAR-DRAFT ORGANIZATION							
	ROVING							
7	Slubber	M	240	.005	12	.1154	.0113	9.79 ± .45
8		L	120	.005	16	.2312	.0154	6.66 ± .43
9	Intermediate	M	240	.001	20	.0453	.0039	8.61 ± .40
10		L	120	.002	17	.0905	.0062	6.85 ± .44
11	Fine Frame	M	240	.0005	12	.01437	.00122	8.49 ± .39
12		L	120	.0005	18	.02875	.00172	5.92 ± .39
	YARN							
13	Regular-draft	M	240	.0001	18	.00287	.00029	10.10 ± .47
	LONG-DRAFT ORGANIZATION							
	ROVING							
14	Slubber	M	240	.005	15	.1141	.0111	9.73 ± .45
15		L	120	.005	19	.2288	.0146	6.38 ± .42
16	Intermediate	M	240	.001	21	.0461	.0035	7.59 ± .35
	YARN							
17	Long-draft	M	240	.0001	20	.00272	.00030	11.03 ± .51

* M indicates the analysis by the mass method.

L indicates the analysis by the lap method.

† The sliver was common to both the regular-draft and the long-draft organizations.

‡ The card, first drawing, and second drawing sliver values are the same as for 22s yarn check test.

Differences between coefficients of variation of at least three times the standard error of the difference have been considered significant. For a difference of three times the standard error, the chances are 370 to 1 that the difference is due to something other than the error of sampling.[2] The ratio of a difference to its standard error is called the "significance ratio" in this report. Significance ratios for the results by the mass method are shown in Table 8; those for the lap method are shown in Table 9.

TABLE 8

Significance ratios for the difference between coefficients of variation of the material fed to and delivered from each process, using the mass method of analysis.

Test	Significance Ratio*						
	First Drawing	Second Drawing	Slubber	Intermediate	Fine Frame	Regular-Draft Spinning	Long-Draft Spinning
22s Test	+ 8.9	−2.4	− 7.4	+0.7	+1.8	−5.0	.....
			− 8.6	+2.0	.....	.....	−7.8
22s Check test	+ 9.6	−5.2	− 7.6	+2.2	+1.4	−2.1	.....
			− 8.2	+4.7	.....	.....	−7.6
28s Test	+10.2	−0.9	−10.0	+3.0	+0.2	−1.7	.....
			− 7.0	+0.4	.....	.....	−5.7
28s Check test	+15.5	+0.1	− 8.3	+0.8	−1.2	−8.6	.....
			− 9.1	−0.1	.....	.....	−5.1
36s Test	(Same as for 22s)		− 7.0	+1.1	+3.1	−7.7	.....
			− 7.6	+2.3	.....	.....	−4.0
36s Check test	(Same as for 22s)		− 8.0	+2.0	+0.5	−2.6	.....
			− 7.9	+3.8	.....	.....	−5.6

* + sign indicates a decrease in irregularity.
− sign indicates an increase in irregularity.

TABLE 9

Significance ratios for the difference between coefficients of variation of the material fed to and delivered from each process, using the lap method of analysis.

Test	Significance Ratio*						
	First Drawing	Second Drawing	Slubber †	Intermediate	Fine Frame	Spinning	
						Regular-Draft	Long-Draft †
22s Test	−3.6	−11.5	− 7.4	−4.2	−3.0	− 8.2	.....
	.....	.....	− 8.6	−2.9	.....	.....	−7.8
22s Check test	−2.4	−14.4	− 7.6	−2.4	−3.5	− 7.7	.....
	.....	.....	− 8.2	−1.8	.....	.....	−7.6
28s Test	−4.7	−11.8	−10.0	−1.5	−4.2	− 5.5	.....
	.....	.....	− 7.0	−3.8	.....	.....	−5 7
28s Check test	+0.6	− 7.7	− 8.3	−3.3	−6.1	− 9.8	.....
	.....	.....	− 9.1	−3.8	.....	.....	−5.1
36s Test	(Same as for 22s)		− 7.0	−4.0	−0.7	−11.5	.....
			− 7.6	−2.7	.....	.....	−4.0
36s Check test	(Same as for 22s)		− 8.0	−3.3	−2.6	− 6.8	.....
			− 7.9	−2.2	.....	.....	−5.6

* + sign indicates a decrease in irregularity.
− sign indicates an increase in irregularity.
† The figures in these columns are the same as those in the corresponding columns in Table 8 by the mass method as there is no doubling.

In preliminary tests and analyses, slight differences were found in the computed results by shifting the position of the class interval units in the preparation of the frequency distributions. In unpublished preliminary tests it was found that the greatest difference produced by such changes was 0.22 in the coefficient of variation and 0.92 in the significance ratio.

Discussion

The irregularity of the material:

If comparisons are made between coefficients of variation of the products of two successive processes, analyzed by the mass method, it will be seen from Table 8 that the following results are indicated:

In four out of four cases the first-drawing sliver is less irregular than the card sliver, and the difference is highly significant in each instance.

In three out of four cases the second-drawing sliver is more irregular than the first-drawing sliver, but the difference is significant in only one of the three cases.

In 12 out of 12 cases the slubber roving is more irregular than the second-drawing sliver, and the difference is highly significant in each instance.

In 11 out of 12 cases the intermediate roving is less irregular than the slubber roving, and, while the difference tends to be significant, it is positively so in only three of the 11 cases.

In five out of six cases the fine roving is less irregular than the intermediate roving, but the difference is significant in only one of the five cases.

In six out of six cases the regular-draft yarn is more irregular than the fine roving, and the difference is highly significant in three of the six cases and nearly so in one other.

In six out of six cases the long-draft yarn is more irregular than the intermediate roving, and the difference is highly significant in each instance.

The change in irregularity through the machines:

If comparisons are made between the irregularity of the product of each machine and the irregularity of the material fed, analyzed by the lap method, it will be seen from Table 9 that the following results are indicated:

In two out of four cases there is a significant increase in irregularity through the first drawing frame; one case shows a decrease in the irregularity, but it is not significant.

In four out of four cases there is a very significant increase in the irregularity through the second drawing frame.

In 12 out of 12 cases there is a significant increase in the irregularity through the slubber.

In six out of 12 cases there is a significant increase in the irregularity through the intermediate, with four of the other cases having significance ratios between 2.2 and 2.9. The other cases also indicate increases in irregularity.

In four out of six cases there is a significant increase in the irregularity through the fine frame, with one of the other cases having a significance ratio of 2.6. The other cases also indicate increases in irregularity.

In six out of six cases there is a very significant increase in the irregularity through both the regular-draft and the long-draft spinning frames.

Viewing Table 9 as a whole it will be noticed that every significance ratio, with the exception of one case for the first drawing frame, shows that there is an increase in irregularity through each machine, and that in the great majority of cases the change is significant. This gives a general idea of the extent to which drafting increases the irregularity of the strands.

In order to show more clearly and specifically the effect of doubling and drafting at each machine upon the coefficients of variation, the tabulation shown in Table 10 has been prepared. The values in the first column are the coefficients of variation of the material delivered from a machine computed by the mass method; the second column contains those for the same material after being doubled preparatory to being fed to the next machine, and are computed by the lap method; the third column contains those for

TABLE 10

Coefficients of variation of material before and after doubling, and after drafting at the next machine.

Material and Test	Coefficients of Variation: As Produced (1)	After Doubling (2)	After Drafting (3)	Hank or Count (4)
Card Sliver, Doubling 6				
22s and 36s test	6.48	2.95	4.03	49.0 Gr.
22s and 36s check test	6.68	3.20	3.95	49.0
28s test	7.81	2.98	4.49	49.0
28s check test	10.54	4.67	4.42	49.0
Average	7.88	3.45	4.22	
First Drawing Silver, Doubling 6				
22s and 36s test	4.03	1.52	4.71	49.0 Gr.
22s and 36s check test	3.95	1.29	5.60	49.0
28s test	4.49	1.48	4.76	49.0
28s check test	4.42	2.05	4.39	49.0
Average	4.22	1.59	4.87	
Second Drawing Sliver, Doubling 1			(1)* (2)*	
22s test	4.72		7.83 8.57	.68 Hank
22s check test	5.59		9.48 9.90	
Average	5.16		8.95	
28s test	4.59		9.38 7.39	.736
28s check test	3.99		7.10 7.56	
Average	4.29		7.86	
36s test	5.29		8.48 8.90	.78
36s check test	5.63		9.79 9.73	
Average	5.46		9.23	
Slubber Roving, Doubling 2				
22s test, regular-draft	7.83	5.41	7.47	1.62
long-draft	8.57	5.99	7.51	
22s check test, regular-draft	9.48	6.82	8.20	
long-draft	9.90	6.28	7.21	
Average	8.95	6.13	7.60	
28s test, regular-draft	9.38	6.85	7.71	1.83
long-draft	7.39	5.35	7.20	
28s check test, regular-draft	7.10	5.20	6.73	
long-draft	7.56	5.68	7.60	
Average	7.86	5.77	7.31	
Slubber Roving, Doubling 2				
36s test, regular-draft	8.48	5.81	7.90	2.07
long-draft	8.90	6.22	7.68	
36s check test, regular-draft	9.79	6.66	8.61	
long-draft	9.73	6.38	7.59	
Average	9.23	6.27	7.95	

Material and Test	Coefficients of Variation: As Produced (1)	After Doubling (2)	After Drafting (3)	Hank or Count (4)
Intermediate Roving, for regular-draft organization, Doubling 2				
22s test	7.47	5.17	6.64	4.58
22s check test	8.20	5.61	7.47	
Average	7.84	5.39	7.06	
28s test	7.71	5.51	7.61	5.50
28s check test	6.73	4.55	7.26	
Average	7.22	5.03	7.44	
36s test	7.90	6.01	6.47	6.58
36s check test	8.61	6.85	8.49	
Average	8.26	6.43	7.48	
Intermediate Roving, for long-draft organization, Doubling 1				
22s test	7.51		12.95	22.0
22s check test	7.21		12.25	
Average	7.36		12.60	
28s test	7.20		10.54	28.0
28s check test	7.60		10.70	
Average	7.40		10.62	
36s test	7.68		10.00	36.0
36s check test	7.59		11.03	
Average	7.64		10.52	
Fine frame Roving, for regular-draft organization, Doubling 2				
22s test	6.64	4.91	9.28	22.0
22s check test	7.47	4.73	8.55	
Average	7.06	4.82	8.92	
28s test	7.61	5.56	8.50	28.0
28s check test	7.26	6.10	13.31	
Average	7.44	5.83	10.91	
36s test	6.47	4.35	11.03	36.0
36s check test	8.49	5.92	10.10	
Average	7.48	5.14	10.57	

(1)* Values for material used for regular-draft organization.

(2)* Values for material used for long-draft organization.

the same material after drafting through the next machine, and are computed by the mass method; the fourth column shows the counts of the material after drafting.

In studying Table 10 it should be remembered that a comparison of the figures in the first and third columns shows the overall change in variability which takes place in each process. This is made up of two parts: first, the decrease in irregularity due to doubling, and, second, the increase in irregularity due to drafting. The table furnishes the data for breaking down the overall change into its two components. For example, the vector difference between a figure in the first and second columns shows how much doubling decreases the irregularity. The vector difference between a figure in the second and third columns measures the degree of variability of drafting. It is possible that a portion of the difference may also be due to the cotton.

The average vector increase in the coefficients of variation, just referred to, has been computed for each machine and is arranged in descending order, in Table 11.

TABLE 11

Average vector increase in the coefficients of variation by machines and the average effective drafts

Machine	Average Vector Increase	Average Effective Draft
Spinning, regular-draft	8.66	5.2
Spinning, long-draft	8.41	15.4
Slubber	7.12	4.3
Fine Frame	4.69	3.0
Intermediate	4.62	2.5
Second drawing	4.60	1.0
First drawing	2.43	1.0

From Table 11 it will be noted that the machines on which no doubling is used, namely, the long-draft spinning and the slubber, occupy positions near the top of the table. The average change in irregularity follows very closely the order of the magnitude of the effective drafts of the machines.

The coefficient of correlation for the values shown in Table 11 is $+0.73$.

In all the tests the yarn was more irregular than the card sliver from which it was made. Overall changes expressed as the percentage increase of the coefficients of variation of the yarn over the coefficient of variation of the card sliver and the corresponding significance ratios are shown in Table 12. In making these comparisons it must be remembered that six inches of card sliver eventually became approximately from 720 to 1200 in. of yarn depending upon the yarn counts spun.

(1)* Values for material used for regular-draft organization.

(2)* Values for material used for long-draft organization.

TABLE 12

Percentage overall increase in coefficient of variation from card sliver through yarn and corresponding significance ratios

Test	Overall Increase		Significance Ratio	
	Regular-draft	Long-draft	Regular-draft	Long-draft
22s test	43.2%	99.9%	5.8	10.2
22s check test	28.0%	83.4%	4.2	9.1
28s test	8.8%	34.9%	1.5	5.0
28s check test	26.3%	1.5%	3.9	0.3
36s test	70.2%	54.3%	8.2	7.0
36s check test	51.2%	65.1%	6.6	7.8

The total and the effective drafts from the first drawing through the spinning are shown in Table 13 for each count, test, and spinning system. The total doublings used for each system of spinning were as follows:

TABLE 13

Total drafts and effective drafts

Test	Total Draft		Total Effective Draft	
	Regular-draft	Long-draft	Regular-draft	Long-draft
22s test	37,090	9,600	130	134
22s check test	34,560	8,630	121	121
28s test	52,820	12,880	183	178
28s check test	53,150	11,040	186	169
36s test	57,270	14,910	199	207
36s check test	55,480	14,650	193	203

regular-draft system, 288; long-draft system, 72. The results do not significantly indicate that the long-draft yarn, with one-fourth the draft and one-fourth the doublings of the regular-draft yarn, is any better or worse than the regular-draft yarn. Significance ratios for the differences be-

tween the coefficients of variation for the two yarn systems are shown in Table 14 for each test and count.

TABLE 14

Significance ratios for the differences between coefficients of variation for regular-draft and long-draft yarns

Test	Significance Ratios*
22s test	+5.0
22s check test	+5.3
28s test	+3.3
28s check test	−3.3
36s test	−1.5
36s check test	+1.3

* Positive sign indicates the regular-draft yarn was less irregular than the long-draft yarn. Negative sign indicates the long-draft yarn was less irregular than the regular-draft yarn.

In two of six cases the yarn produced on the regular-draft system of spinning was more irregular than that produced on the long-draft system. In four cases the difference in irregularity between the two yarns is significant, but one shows the greater irregularity of the regular-draft yarn to be significant, and three show the greater irregularity of the long-draft yarn to be significant.

It must be kept in mind that this study does not and is not intended to duplicate commercial manufacturing conditions. The outstanding difference is that one and the same delivery or spindle was used throughout at each machine. This eliminated many variables, thus enabling the analysis to be more clearly confined to the effect of the machine upon irregularity. Commercial manufacturing processes tend to submerge the differences in irregularity caused by a machine. It is possible, in the case of an organization similar to one employed in this study, that the finished yarn is produced from the products of two fine frames, four intermediates, eight slubbers, eight second-drawing deliveries, 48 first-drawing deliveries, and 288 cards. Also, manufacturing procedure produces a more or less random distribution of the products of one machine or delivery, so that it is very improbable that the product of any one delivery is fed double at any successive machine.

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Determination of Fibre Fineness and Cross-Sectional Variability

An Improved Technique for Obtaining Photomicrographs by Projecting Cross-Sections on Sensitized Paper

By J. I. HARDY *

SINCE the first utilization of wool in industry there has existed a need for accurate information on the measurement of fineness and variability of its fibres. Paralleling the recognition of this need there has been a corresponding effort on the part of investigators [1] to improve the technique required for the determination of fineness.

In 1864 Nathusius [2] reported the irregularity he had found in the cross-sectional contour of wool fibres. In spite of this report most width measurements on wool fibres have been taken in one direction only, because the time ordinarily required for making cross-sections rendered other procedure impractical. Furthermore, average width measurements on a large number of fibres from a wool sample yielded a satisfactory relative value for fineness for wool top and grades of wool where the fibres were quite uniform.

By using a cross-sectioning device invented by the writer,[3] and reported in an earlier issue of *Textile Research,* he has developed an improved technique for examining and measuring fibres. The fibres are projected and then measured by a modification of the rapid wedge measuring method reported by Lauth [4] and later by Von Bergen.[5] The fineness and diameter variations are then easily determined. There is, however, an added advantage to this method in that there is a photographic record of all the fibres of the cross-section in one focal plane. These photomicrographs furnish a most efficient means of ob-

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serving fineness and variability of the fibres for the sheep breeder, manufacturer and others interested.

Improved Device and Equipment

In this method the cross-sections are obtained by using an ordinary safety razor blade and the cross-section device illustrated in Fig. 1. Both the fibre holder and slide holder are 3/64 in. (1.19 mm.) in thickness. The shape of the fibre holder and slide holder when assembled is that of an ordinary microscope slide, 1 in. (25.4 mm.) wide and 3 in. (76.2 mm.) long. The fibre holder and slide holder are each 1½ in. (38.1 mm.) long. This change in shape of the device makes it more convenient to use and permits the addition of two supporting guides on the fibre slide. The width of the fibre slot is 0.0085 in. and its length is ⅜ in.

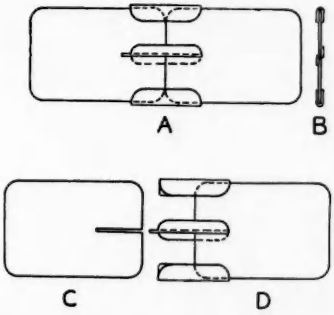

FIG. 1. Device for holding fibres for cutting cross-sections. (A) Top plan view of the whole device. (B) End plan view of slide holder. (C) Top plan view of the fibre holder disc, showing the fibre slot. (D) Top plan view of the slide holder.

The first part of the device involves the use of a fibre holder in which there is a fibre slot cut in the middle of one end of the fibre holder, and extending ⅜ in. toward its center. The second part is designated as the slide holder, in which is rigidly held a flat-surfaced metal slide with right-angle flanges. This slide extends sufficiently beyond the slide holder so that when in position the unfilled span in the bottom of the slot is 1/32 in. On each side of the slide holder is a guide which keeps the fibre holder steady. These guides help hold the fibre and slide holder together.

The other equipment consists of laboratory and dissecting microscopes, a projection microscope equipped with a right-angle prism, a small dark room, sensitized paper, developing solutions, and a celluloid wedge measure. This wedge measure consists of a sheet of celluloid 20 in. long, 4 in. wide and 0.0020 in. in thickness. On the surface of this celluloid is an inner and outer wedge measure. The inner and outer wedges are each 50 cc. long. They are graduated, each centimeter along their lengths, with lines extending across the inner and outer wedges. For each 20 mm. increase in the

length of the wedges there is a corresponding increase of 1 mm. in their widths. The inner wedge ranges in width from 5 to 30 mm. while the outer measures from 30 to 55 mm. With 500 diameters magnification, each micron on the unmagnified cross-section is equal to one-half mm. on the wedge. For convenience the wedge measure is graduated to read direct in microns, from 10 to 60 on the inner and from 60 to 110 on the outer. There is a small hole through the celluloid at each millimeter interval along its length, which permits the numbering of the fibres and recording the direction in which measurements are made.

Method of Procedure

A small lock of wool fibres is cleaned with carbon tetrachloride and dried between blotting paper. From this is separated a strand of fibres, about 1 mm. in diameter and containing usually over 100 fibres. This strand of wool is inserted in the fibre holder and the slide of the slide holder is pushed into the fibre slot until the strand of fibres is held securely in place. The fibres are then cut off flush on both sides of the fibre holder by means of a safety razor blade. With a little practice and sharp razor blades, good cross-sections are easily cut in less than one minute. Best results are secured by observing the position of the razor blade, while cutting, by means of a binocular magnifying about 12 diameters. The cross-section is examined under an ordinary microscope by using direct illumination and 100 diameters magnification. If the fibres are all sharply defined and not crowded together, the cross-section is ready to be taken into the dark room and projected with the projection microscope. If the fibres are not cut smoothly and all in the same plane, a new cross-section should be made. Should the fibres appear to be packed too tightly, the slide holder is withdrawn until the individual cross-sections of the fibres stand out in relief when examined under the microscope. The cutting of very fine fibres may be facilitated by allowing a thin solution of celluloid in acetone to dry on the fibres in the fibre holder before cutting.

The cross-section device is placed on the stage of the projection microscope and the cross-section is focused upon a sheet of white paper. A magnification of 500 diameters is used as it makes 0.5 mm. on the image equal to 1 micron and avoids unnecessary calculations. Cross-sections are most conveniently measured or photographed upon a horizontal surface. This may be done with either a vertical projector or a horizontal projector equipped with a right-angle prism to deflect the image downward.

The projected images of the cross-sections may be measured as projected or photographed by projecting on a sensitized paper and measured after developing, fixing and drying of the negative. If measured in the dark room the paper wedge measure used by Lauth[4] and Von Bergen[5] is most satisfactory, inasmuch as the diameter distribution curve of the fibres is obtained as the diameter of each fibre is recorded.

Photomicrographs of cross-sections of fibres are measured with greater convenience and less fatigue than their images as projected in the dark room. The process of measuring width is essentially the same in either case and consists in fitting the image of each fibre cross-section between the lines of the wedge and recording the width to the nearest micron. The tabulating of results is facilitated by having sheets of paper numbered in microns, from 10 to 110 consecutively, so that the distribution may be

recorded as measured. A sheet of thin cardboard may be attached to the edge of the celluloid wedge for the purpose of recording the fineness frequency, as the fibres are measured. One hundred fibres were measured in two directions for the results reported in this paper.

The shapes of fibre cross-sections vary widely. Although some are perfectly circular in shape, as a rule they are irregular and often have varying degrees of ovality. According to Barker[6] greater circularity of fibre form is associated with better spinning properties. When not circular a more accurate measure of fineness is obtained by measuring the diameter of each fibre in the direction of its greatest and smallest widths and using an average of these two widths as the fineness of each fibre. New possibilities in the interpretation of wool fineness are opened up through the fineness analysis of fibre cross-sections. The average of the greatest and least thicknesses of each fibre in a sample of wool gives a reliable measure of its average fineness and the difference between these two values furnishes a measure of its ovality. The distribution of the fibres according to their greatest and least thicknesses furnishes data from which any sample of wool may be closely defined.

The Bureau of Animal Industry, U. S. Department of Agriculture, in its sheep-breeding investigations uses standard samples, the cross-sections of which have been examined for shape and distribution of fibre. In this connection it has been found that a sample with a wide distribution of fibre diameter or a very pronounced ovality is unsuitable for a standard sample, as it may seem finer or coarser than it really is and not appear of the same fineness to different individuals who may be using it.

In addition to the cross-sectional contour of fibres other details are shown such as the presence and distribution of kemp and medulated fibres.

Application, Qualitative and Quantitative

The simplicity of the foregoing procedure for making cross-sections and obtaining their photographic record gives it a wide application in the study of fibres in both production and utilization fields. These cross-section photomicrographs with all the fibres lying in the same focal plane and at a known magnification furnish a good basis for qualitative judgment as to the type, size, and distribution of the fibres. A cross-section of a tuft of fibres, on examination under the microscope, may furnish all the information desired; however it is frequently necessary to compare several samples in order to select those which are the most outstanding in some particular characteristic. In such instances, photomicrographs of fibres greatly magnified simplify the selection of outstanding individual samples. An example of such application would be in the selection of breeding animals for uniformity of fibre in wool production.

Breeders have made notable progress in the improvement of the wool of their flocks. This has been brought about in spite of the difficulty of judging fineness and uniformity with the unaided eye and without an established standard of fineness for wool of different breeds. There is naturally a difference in the fineness in the same breed produced by different breeders, in addition to the variations in fineness found in different flocks. Figs. 2, 3 and 4 illustrate this point. These cross-sections were made of samples taken from the left sides of three purebred sheep. The sections illustrated in Figs. 2 and 3 were taken from one flock and those in Fig. 4 from another.

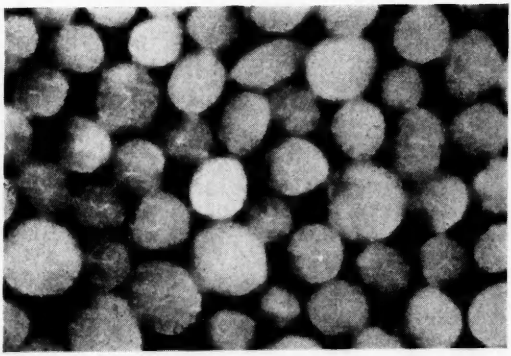

FIG. 2. Photomicrograph of cross-sections of wool fibres from the side of a purebred sheep, illustrating good uniformity and indicating animal desirable for breeding purposes, × 500.

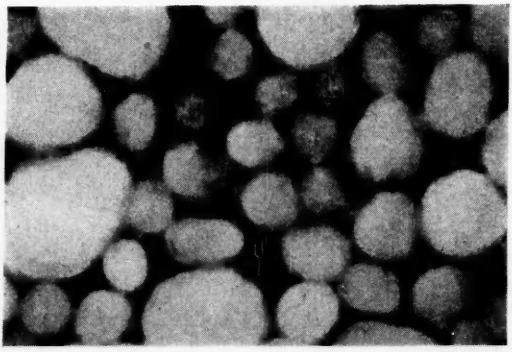

FIG. 3. Photomicrograph of cross-sections of wool fibres from the side of a purebred sheep, illustrating poor uniformity and indicating animal not desirable for breeding purposes, × 500.

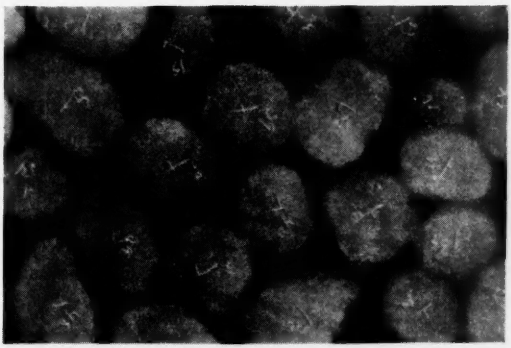

FIG. 4. Photomicrograph of cross-section of wool fibres exceptionally uniform but having pronounced ovality of fibre, × 500.

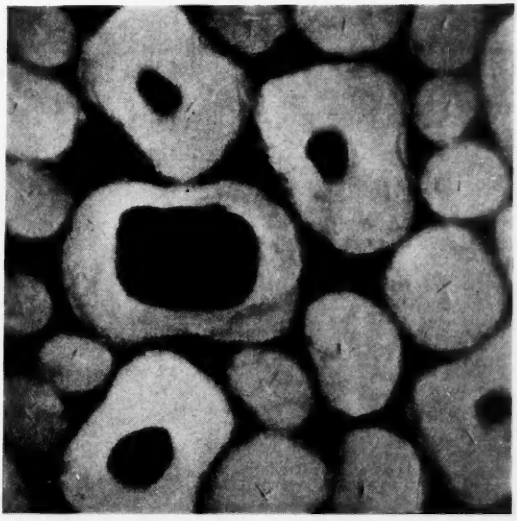

FIG. 5. Photomicrograph of cross-section of wool fibres of Navajo wool. Note the medullated fibres with black centers, variation in fibre fineness desirable for hand carding and spinning, × 500.

The cross-section of the fibres for Figs. 2 and 4 are both quite uniform but widely different in fineness, although 4 shows greater ovality than 2. Fig. 3 lacks uniformity, having a mixture of fine and coarse fibres, with the fine predominating. Assuming that the sheep producing wool of a uniformity indicated by the cross-sections 2 and 4 were the result of several generations of careful breeding, the mating of animals producing wool with such a difference in fineness would introduce irregularities requiring several generations to correct. The wool shown in 2 and 3 is from the same flock. Two is very uniform, while 3 is lacking in uniformity, due to the presence of some coarse fibres. Fig. 5 is a photomicrograph of a cross-section of wool from the side of a Navajo sheep, a type native to Arizona. This illustrates the wide range in fineness found in this kind of wool. The large fibres with the black centers are heavily medullated. Sheep with these fibres on the side and shoulder usually have kemp on the thigh. Fig. 5 also shows many fine fibres which in a fleece are referred to as "bottom wool." Such a fleece with long, coarse, outer fibres and a fine bottom wool is adapted to the hand-spinning of yarn for the weaving of rugs. Through the aid of photomicrographs an easy means is afforded of selecting animals which have the desired fineness and distribution of fibres.

While it is necessary to perform the details of making cross-sections of fibres in a laboratory, photostat copies of the photomicrographs showing the precise details seen under the microscope, may be furnished sheep breeders at a very small cost. They also assist in other lines of breeding work with both plants and animals, where fineness, distribution and shape of fibres require special consideration. Another application is in the examination of textile and allied fibers where examination and records of fineness and distribution are frequently required on raw wool, wool top, yarn, hair, bristles and other fibres.

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Silk Degumming

Part III.—Rate of Boiling-Off Silk Hosiery

By O. A. HOUGEN*

Abstract

The theory of silk degumming developed in Part II is applied to practical conditions of boiling-off silk hosiery. About 80 tests were conducted on 10 pound lots totaling over 1000 dozen pairs of stockings, besides tests on loads up to 500 pounds each. Operating conditions employed in boiling-off hosiery are reviewed. At 200° F., with a water ratio of 20 to 1, in a reciprocating drum on 98 denier silk soaked in a soluble sulphonated oil, the values of k *for different alkalies and for soap were found to be as follows: (Values of the degumming coefficient,* k_1*, on the pound basis are given for comparison.)*

Reagent			k (equivalent basis)	k_1 (pound basis)
Soap .01 Normal			184	.605
.02 "			152	.500
.04 "			104	.342
.06 "			71	.233
.08 "			49	.161
.10 "			33	.108
Sodium hydroxide			144	3.60
Sodium carbonate			121	2.27
Sodium silicates				
Ratio of SiO_2/Na_2O	$\%Na_2O$			
1.0	10.5		175	.595
1.63	19.4		164	1.025
2.62	29.9		101	.975
3.73	8.9		61	.175
Trisodium phosphate			51	.400
Borax			28	.147
Sodium bicarbonate			25	.298

For soap solutions $\log_{10} k = 2.236 - 8.21\ N_0$ *where* N_0 *is the initial normality. The most rapid rate of degumming in soap occurs at a normality of* $1/(2.3)\ (8.21) = .053$ N. *Values of* k *vary inversely with the 3/4-power of yarn denierage. The temperature coefficient of* k *was enormous, increasing three-fold from 180° to 200° F. and may be represented by the equation* $\ln k = -20900/T + b$ *where* T *is in degree Rankine.*

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An increase in agitation increases the value of k, *due to an increased rate of diffusion. For a given rate of rotation the coefficient* k *seems to be independent of the size of machine. Values of* k *were 30% higher for yarns soaked in a soluble sulphonated oil than when soaked in a soap-fixed oil combination. Values of* k *seemed highest for a loading of one pound of stock to 20 pounds of water. Correction factors for temperature and yarn size are given, also the time schedule for boiling-off hosiery with different concentrations of soap and sodium carbonate.*

Introduction

MOST silk and hosiery mills have at some time in their existence established for themselves the proper schedule for boiling-off silk hosiery. Each mill has carried out its own separate experiments without making any effort to publish the results or to solve the problem co-operatively. This paper is planned, not to present the ideal conditions in boiling-off silk hosiery nor the remedies for troubles encountered, but rather to present an application of reaction kinetics to large scale experiments, such as each mill goes through separately in determining for itself suitable conditions of operation. It is the aim of this paper to express numerically information which is generally known in a qualitative sense. In a previous paper [60] the chemical kinetics of silk degumming applied to laboratory tests were presented; the same study will now be applied to large-scale tests. The experimental data are based largely upon plant tests at the Holeproof Hosiery Company, Milwaukee, Wis.

Methods of Boiling-off Silk Hosiery

Quoting from the bulletins on Silk Degumming of the Textile Research Division of Procter and Gamble:

"The purpose of boiling-off silk hosiery is three-fold; to remove the sericin content, to remove the reagents added by the throwster in soaking raw silk and to remove any incidental dirt picked up in any of the operations of reeling, throwing, or knitting. . . . Boiling-off is the most important process in finishing silk because it influences to a large extent the physical properties of the silk fiber as represented by the luster, hand and wearing qualities of the finished fabric." [31]

The usual method of boiling-off is to agitate the stock in a soap bath inside a reciprocating drum. Usually, hosiery is degummed in a single

bath, although the Textile Research Division of Procter and Gamble recommend a double bath process.[34] Roberts[38] points out the value of the still-bath method for sheer, delicate fabric to eliminate dangers of mechanical agitation.

The foam method was developed by Schmid[41] in 1906, but its use has been restricted chiefly to degumming skeins of raw silk because by this method tangling is minimized.[7, 9, 13] Claims are made that this method reduces friction and chafing, gives a better feel and luster, improves winding and cohesion, and is more economical of space, labor and soap.[7]

The use of an olive oil or oleic acid soap has been quite universally recommended for boiling-off silk.[30, 31, 46] Soap in general is the best degumming agent since it supplies the alkali required for reaction with sericin at a slow rate without damage to the silk fibre, and, in addition to its mild chemical action, it combines the property of removing and emulsifying any oil or dirt present in the stock.[30, 31] Olive oil or oleic acid soap is desired in particular because of its low titer, low rate of hydrolysis, high solubility and ease of rinsing from the fabric.[31] These soaps are particularly resistant to oxidation and rancidity and leave the silk soft and lustrous. Tsunokaye[54] states that the degumming power of a soap is proportional to its degree of hydrolysis; olive oil soap is particularly suitable for silk degumming because of its low degree of hydrolysis, whereas tallow soap is objectionable for the opposite reason. In degumming with soap, alkali is consumed and a fatty acid soap results. According to Takahashi this acid soap is adsorbed by the fibre and protects it from action by alkali.[49, 50] The adsorbed acid soap is said to retard the rate of degumming. The amount of soap added to the boil-off bath is usually based on the silk content of the bath. Procter and Gamble[32] recommend 20 to 25% flake soap (soap content 92%) for Japanese silk having a sericin content of 18%. For Canton silk containing 24% sericin a proportional increase in soap is advocated. Furthermore, "a heavy, tightly twisted and closely woven fabric requires a higher concentration of soap than a loosely knitted tram." Soap concentrations up to 50% have been recommended for boiling-off hosiery.

The amount of water used in boiling-off silk varies from 10 to 50 pounds per pound of stock. Roberts[38] states that in the still-bath method the low ratio may be used. Bray, Crowe and Meeker[15] recommend 40 to 50 times the weight of stock, a ratio above 50 gives unnecessary dilution and below 20 produces chafing and bag marks.

Roberts[39] lists a variety of reagents used for degumming silk. Sodium silicate in combination with sulphonated oils is used with marked success provided care is taken to maintain the pH of the bath below 10.5. The presence of sulphonated oil, such as sulphonated castor oil, improves wetting and penetration in boiling-off and is said to impart a soft feel to the silk.

The use of alkalies alone in boiling-off hosiery should never be employed since they leave the stock "dirty, yellowish, thin and harsh."[30] Strong alkalies also diminish the luster, tenacity and elasticity of silk.[57] Alkalies successfully remove sericin by chemical reaction, but do not possess the detergent properties of a soap necessary to remove dirt and oil. The use of alkaline baths having a pH above 11 are always dangerous because of certain destructive action on the silk fibre itself. In conjunction with soap, alkalies have been successfully used. This is permissible because of the buffering action of soap and sericin.[42] Some discourage the use of

alkalies entirely stating that control of pH of a soap bath by addition of alkali is not reliable.[32] Others find the addition of mild alkalies satisfactory.[18] Toyoda[53] states that the use of alkalies with soap seems better than soap alone, and that in degumming silk may remain as long as one hour in .001 normal sodium hydroxide or 0.0067 normal sodium carbonate solutions in conjunction with soap without any injury to the fibre. The use of small amounts of sodium carbonate, modified sodium carbonates and trisodium phosphate in the boil-off bath in conjunction with soap is common practice.

Enzyme degumming of silk and degumming by acids have been used in special cases where low temperatures must be maintained, or where mixtures of silk with wool or Celanese are encountered. Such unusual practices are discussed by Mosher.[28, 29]

It has been definitely established by Mosher[30] that the pH of the boil-off bath in alkaline degumming should be maintained between 9.5 and 10.5. Below a pH of 9.5 the rate of degumming is too slow, causing prolonged exposure to mechanical damage; above 10.5 the danger of chemical damage rapidly increases. Degumming is slow and incomplete at a pH below 8.4.[42] Attempting to shorten the time of boiling-off by increasing the pH above 10.5 by addition of alkalies invites trouble. Because of the buffering action of soap and sericin, control of pH between the limits of 9.5 and 10.5 by the addition of alkalies is simple.[42] However, too much reliance should not be placed upon pH control in boiling-off silk. A well-buffered soap solution, to which caustic soda is added, may still be dangerous even though its pH is below 10.5.

Careful temperature control in the boil-off bath is a most important requisite. The temperature coefficient of reaction rate is enormous; the instantaneous rate of degumming for a given sericin content and alkali ratio more than doubles for each 10° C. rise in temperature. For hosiery the simplest means of temperature control is to maintain at a gentle boil; for skein goods this is prohibited because of danger of tangling.[32] Below 180° F. the rate of degumming is entirely too slow for practice. With thermostatic temperature control it is desirable to maintain the temperature of the boil-off bath between 205° and 210° F.[15]

The degree of agitation to employ in the boil-off bath obviously depends upon the nature of the stock. Procter and Gamble maintain that agitation produced by a gentle boil is sufficient and that mechanical tumbling of goods produces chafe marks.[32] The use of slowly reciprocating drums is common practice in boiling-off hosiery. The demand for the use of soft water in the boil-off bath is universal.

Rate of Boiling-off Silk Hosiery

The rate of boiling-off silk hosiery can be varied between any limits by control of temperature and reagents. A high rate of boil-off is objectionable because of the danger of chemical damage to the silk fibres; likewise a low rate of boil-off may be objectionable in that a prolonged exposure results in mechanical damage, such as chafing, creases and bag marks.

In a previous paper[60] the chemical kinetics of degumming silk were presented. The boiling-off of silk hosiery is more complex than the degumming of raw silk in that the former operation involves the removal of

soaking reagents added by the throwster, of dirt and oil incidentally accumulated during reeling, throwing, and knitting. Besides, the special construction of a stocking, such as the presence of seams and union with cotton or rayon, introduces complications.

The fundamental degumming equation was previously reported [60] as

$$\frac{dS}{d\theta} = -(c + kA)S \qquad (1)$$

where S is the instantaneous sericin content of the silk expressed in pounds per pound of dry, clean silk.

θ is the time elapsed, in minutes.

A is the instantaneous ratio of alkali or soap to silk, expressed in pound equivalents per pound of dry, clean silk.

c is the degumming coefficient in pure water.

k is the degumming coefficient due to the presence of soap or alkali.

Experimental Procedure

In a typical experimental run 10 pounds of stockings in the gum were divided equally into three boil-off nets weighing 0.9 pound each. In separate experiments two styles of stockings were used representing different soaking emulsions and different size yarns. The fabrics analyzed as follows:

Style	A	B
Denierage of silk	128 7-thread	70 5-thread
Moisture (conditioned)	9.9%	9.9%
Cotton fibre (dry)	40.3	25.0
Silk fibre (dry)	37.3	46.5
Sericin	9.6	12.0
Addition agents (added by throwster)	2.9	6.6
Number of stockings	210	

On the basis of the dry, sericin-free silk the silk yarn analyzed:

	A	B
Total boil-off content	33.5%	40.0%
Sericin	25.8	25.7
Addition agents	7.7	14.3

On the usual basis of dry, thrown silk the total boil-off content becomes: A yarn, 25.1%; B yarn, 28.6%.

Yarn A represents raw silk soaked in a soluble sulphonated oil emulsion giving a low absorption of oil; yarn B represents soaking in a thicker emulsion of soap and fixed oils giving a much higher take-up of reagents.

The test stockings were boiled-off in a bath containing 200 pounds of water plus boil-off reagents. All runs were conducted at 200° F. A small one-pocket boil-off drum was used, reciprocating 2.4 times per minute at a rate of 4.8 r.p.m. Data for determining degumming coefficients were obtained by removing samples of boil-off liquor at 0, 5, 10, 15, 20 and 45 minutes and analyzing each solution for sericin and total solid contents. This method differs from the procedure followed in the previous investigation [60] in that here the emulsion instead of the silk was analyzed.

On large-scale tests this method seems better since it is easier to obtain a representative sample of the bath than of the stock. Different stockings in a bath do not degum at the same rate, those on the outside of the load degum more rapidly than those on the inside. A typical experimental run will be illustrated wherein 0.30 pound of sodium carbonate was used as the degumming agent in conjunction with 0.72 pound of sulphonated castor oil (30% water). The sulphonated oil has no degumming action as will be shown later. Two hundred cc. samples of boil-off liquor were removed at each time stated. Of these samples 25 cc. aliquots in duplicate were taken and analyzed for total residue by evaporation to constant weight at 220° F.

Time in Minutes	Weight of residue per 25 cc. sample in grams
0	0.1057
5	.2210
10	.2509
15	.2630
30	.2752
45	.2808

Values of pH were recorded on all samples. The original 0.1057 gram corresponds to the initial alkali and oil content of the bath together with the mineral content of soft water. The increment of value in the other samples is due to the presence of sericin and soaking reagents from the silk. The weight of a 25 cc. sample was obtained from density measurements as 25.1. The total weight of the boil-off bath, neglecting stock, was equal to W + r, where W is the weight of water and r is the weight of residue in the bath. The factor for calculating the total weight of residue in bath is accordingly $\frac{W + r}{25.1}$. The initial value of W was 200 pounds, but decreased due to removal of water by evaporation and sampling. The evaporation at 200° F. amounted to 13.3 pounds per hour. The water removed in each sample was 0.4 pound. The total water content W of the bath at various times was therefore

Time in Minutes	Pounds
0	200
5	198.1
10	196.6
15	195.1
30	191.4
45	187.7

A correction should also be made for the weight in pounds of solids removed by each 200 cc. sample, which is equal to .0176 times the weight in grams of residue in each 25 cc. sample. The soft water used contained a solid residue of 204 parts per million, which corresponds to 0.041 pound in a bath of 200 pounds of water.

The total residue in the boil-off bath calculated from the above experimental data is tabulated in Table I.

TABLE I

Time in minutes	Residue in 25 cc. sample grams	Factor* for entire bath	Total Residue in Bath in Pounds	
			Uncorrected	Corrected for sampling
0	.1057	8.00	0.843	0.843
5	.2210	7.96	1.760	1.765
10	.2509	7.90	1.980	1.990
15	.2630	7.85	2.065	2.08
30	.2752	7.70	2.120	2.14
45	.2808	7.55	2.120	2.145

The final value of 2.145 represents an equilibrium value corresponding to complete degumming. Subtracting from the values in the last column the initial value of 0.843, corresponding to the original boil-off reagents used and solid content of soft water, the boil-off content of the bath removed from the silk is obtained. Dividing these values by 3.73, the weight of dry, clean silk, the boil-off content of the bath per pound of dry clean silk was obtained, giving an initial boil-off content of 0.349.

The boil-off content residual in the silk per pound of dry clean silk is then obtained by subtracting each value in the first column of Table II from 0.349. These values usually correspond to the sericin content of the silk, except at zero time when the value is 0.258.

* Correcting for evaporation and sampling.

TABLE II

Time in Minutes	Pounds per pound of dry clean silk		
	Boil-off Content		Sericin Content
	in bath	in silk	of silk
0	0	.349	.258
5	.247	.102	.102
10	.307	.042	.042
15	.331	.018	.018
30	.348	.001	.001
45	.349	0	0

This method, if properly conducted, automatically corrects for losses such as water and carbonic acid due to reaction of alkali with sericin.

In boiling-off this silk at 200° F. all of the soaking reagents were removed very rapidly leaving the sericin to be removed at a slow rate. The removal of boil-off reagents is so rapid

as to be neglected, and the general degumming equation can then be applied by integration from an initial value of 0.258 corresponding to the initial sericin content of the silk. In the case of yarns such as Style B, soaked to a high boil-off content with soap and non-soluble oils, part of the reagents go off slowly along with the sericin. For example, with Style B the integration should be started with an initial value of .32, which corresponds to the sericin and includes the portion of soaking reagents slowly removed.

The initial alkali content of the bath, A_o, in pound equivalents per pound of dry, clean silk is

$$\frac{(0.30)(.0189)}{3.73} = 0.00152.$$

From a weight balance $$A_0 - A = \frac{S_0 - S}{B} \qquad (2)$$

where S_o is the initial sericin content of the silk, 0.258, and B is the binding weight of the sericin, equal to about 1600.[80]

Equation (1) upon integration becomes

$$2.3 \log_{10} N = (c + ak)\theta \qquad (3)$$

where $$N = \frac{S_0}{S} \frac{\left[c + k\left(a + \frac{S}{B}\right)\right]}{\left[c + k\left(a + \frac{S_0}{B}\right)\right]} \qquad (4)$$

and $$a = A_0 - \frac{S_0}{B} = .00152 - .000162 = .00136.$$

When c is small compared to kA, Equation (3) becomes

$$2.3 \log_{10} N' = (c + ak)\theta \qquad (5)$$

where $$N' = \frac{S_0}{S} \frac{\left(a + \frac{S}{B}\right)}{\left(a + \frac{S_0}{B}\right)}. \qquad (6)$$

Equation (5) may be used in all practical boil-off runs where the amount of alkali used is relatively large.

Values of N′ are obtained by substituting the known values of S_o, S, a, and c. When N′ is plotted against time on semi-log paper a straight line is obtained, the slope of which is equal to $\frac{c + ak}{2.3}$. By substituting known values of c and a the degumming coefficient, k, is obtained. The evaluation of constants is shown graphically in Fig. 1.

The slope of the curve in Fig. 1 is equal to $\frac{\log 30}{20} = 0.0738$

hence $$k = \frac{(2.3)(.0738) - c}{a} = \frac{1.70 - .009}{.00136} = 118.$$

Where values of kA are relatively small compared to c it will be necessary to re-evaluate k by substituting the approximate value into Equation (4) to find N, then plotting N against θ on semi-log paper to find the corrected value of k. However, values of k cannot be obtained accurately where low concentrations of alkali are involved until the value of B is known more precisely.

The degumming coefficient k is dependent upon many operating variables such as temperature, kind of alkali or soap, concentration of reagents, degree of agitation, size of yarn and construction of fabric. It became the purpose of these tests to evaluate the coefficient k in terms of the many operating variables encountered in boiling-off hosiery.

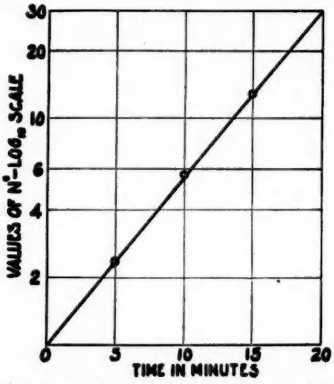

FIG. 1. Evaluation of degumming coefficient k.

Effect of Temperature

Temperature is the most important operating variable in boiling-off silk. The degumming coefficient k increases enormously with increase in temperature. The high temperature coefficient of the reaction velocity constant is definite proof that silk degumming is a chemical process and not one of dispersion following adsorption. The following data were obtained from tests on Style A stockings and also calculated from tests made by the Textile Research Division of Procter and Gamble on degumming crepe silk:

TABLE III

Effect of Temperature

Data from Procter and Gamble on crepe silk boiled-off with 50% soap.
$A_o = .00222$. $a = .002057$

Temperature	k
200° F.	31.5
190	11.8
180	4.2
160	0.02

Tests on Style A stockings (5 thread, 70 deniers)

10 lbs. stock. Initial normality of soap, 0.030N
200 lbs. water $A_o = .001314$
2.0 lbs. soap. $a = .001114$
0.036 lb. sodium sesquicarbonate.

Run No.	Temperature	Slope	k
13	212	.0790	149*
10	200	.0573	100
12	180	.0176	33*
15	130	.0023	4*

* Not corrected for coefficient c.

The effect of temperature upon a chemical reaction velocity constant can usually be expressed by the Arrhenius equation

as $$\frac{d\ln k}{dT} = \frac{A}{RT^2} \tag{7}$$

or $$\ln k = -\frac{A}{RT} + b \tag{8}$$

where A is called the energy of activation and
R the usual gas constant, 1.985.

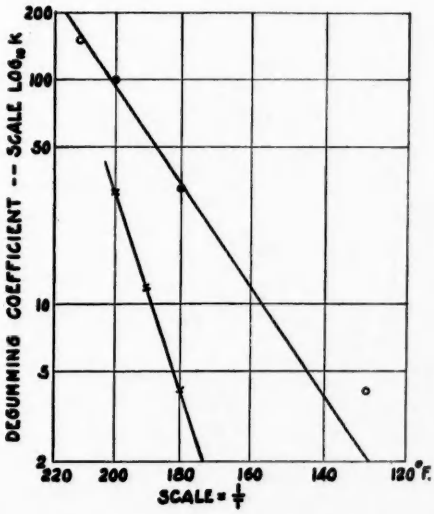

FIG. 2. Effect of temperature upon degumming coefficient. ˣ Data by Procter and Gamble. ° Data by Hougen.

When $\log_{10}k$ is plotted against the reciprocal of absolute temperature a straight line results with both sets of experimental data (Fig. 2). For tests on the boiling-off of hosiery the equation for k becomes

$$\ln k = -\frac{20{,}900}{T} + 36.25 \tag{9}$$

where T is in degrees Rankine.

Increasing the temperature from 180° F. to 200° F. increases the degumming coefficient from 33 to 100, a three-fold increase in the rate of boiling-off for a 20° F. temperature rise, other conditions remaining constant.

All subsequent tests were conducted at 200° F.

Boiling-off With Water Alone

When silk hosiery is boiled-off with hot water alone, soaking reagents are removed rapidly but the sericin is but slowly affected. With Style A yarn all the soaking reagents were removed rapidly; with Style B about one-half of the reagents was held by the sericin and went off slowly with the sericin. The rate of boil-off when water alone is used is influenced by the nature of soaking reagents; the presence of soap or alkali as soaking reagents aids in the degumming process. The following data were obtained with Style B stockings.

TABLE IV

Effect of Water Alone

10 pound stock (Style B, 5 thread) 200 pounds water, 200° F.

Time	Boil-off Content	S	S_0/S
0	.384	.320	1.00
5	.305	.305	1.062
10	.286	.286	1.125
15	.276	.276	1.19
30	.238	.238	1.34

The value of c, the degumming coefficient with water alone, is obtained from the equation

$$\frac{dS}{d\theta} = -cS$$

where

$$c = \frac{2.3 \log_{10} \frac{.32}{S}}{\theta} = .0091 \qquad (10)$$

Effect of Alkalies and Alkali Concentration

Mild alkalies are extensively used in boiling-off silk in conjunction with sulphonated oils or with soap. When used in conjunction with sulphonated oils it is the alkali alone which exerts degumming; the sulphonated oil has no degumming power, its purposes being to prevent the yellow discoloration which results from the use of alkali alone, to produce level dyeing, and to impart a soft feel to the fabric. In these tests it was found that the sulphonated oil neither retarded nor hastened the boil-off. The use of sulphonated oils in conjunction with alkalies is particularly desirable when boiling-off and dyeing are performed in a single bath. From experimental results on degumming with various alkalies and in various concentrations it was found that, within experimental error, the degumming coefficient k

was independent of pH, or alkali concentration, but did depend upon the nature of the alkali with the following results:

	Style A (98 denier)	Style B (70 denier)
Sodium silicates	k	k
(M) $SiO_2/Na_2O = 1.0$ (10.5% Na_2O)	175	
(B) " 1.63 (19.4% Na_2O)	164	
(S) " 2.62 (29.9% Na_2O)	101.5	
Na_2CO_3	122	121

With sodium silicates the degumming coefficient decreases with increasing ratio of SiO_2 to Na_2O.

Effect of Soap and Soap Concentration

Boil-off tests were carried out with olive oil soap and oleic acid soaps in various concentrations. It was found that soaps behaved very differently from alkaline solutions, such as alkali silicates or carbonates, in that the degumming coefficient varied markedly with concentration. Soap concentrations were varied from 2.5 to 60% of the weight of the stock, or in initial normality from .004 to .090 N. When the logarithm of k was plotted against initial normality the points fell on a straight line, with the exception of low concentrations where results were erratic. (Fig. 3). The

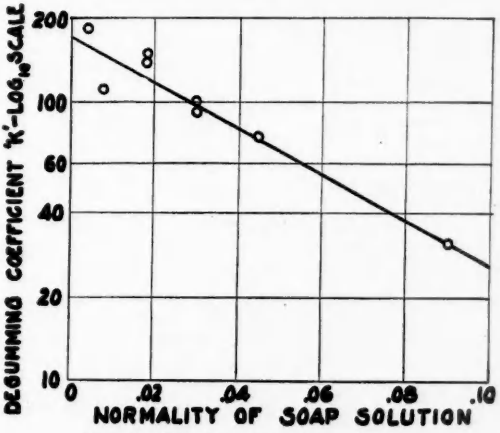

FIG. 3. Effect of soap concentration.

small amount of alkali present in some of these tests would not seriously alter the reported results. With soap solutions alone the degumming coefficient, k, can be expressed by the equation

$$\log_{10} k = -8.21\, N_0 + 2.236 \qquad (11)$$

where N_o is the initial normality of the soap solution. This equation holds for the experimental range of normalities up to 0.1 N solutions. It will be observed that, on the basis of unit weight, soap is increasingly more effective as its initial concentration diminishes. An increase in soap concentration decreases the degumming coefficient. The rate of degumming is hence not directly proportional to soap concentration but less than a direct proportional ratio. This situation is in accord with other properties of soap solutions. With increasing dilution with water soap solutions behave more and more like true solutions and gradually lose their colloidal properties so familiar in concentrated solutions. Increased dilution increases the hydrolysis of soap and the chemical activity of the dispersed particles.

In general the degumming coefficient of a soap solution may be expressed by the equation

$$\log_{10} k = -8.21\, N_0 + b \qquad (12)$$

or

$$\ln k = -18.9\, N_0 + 2.3\, b \qquad (13)$$

As proved in a previous paper,[60] it can be shown from differential calculus that the minimum time of boiling-off occurs at a soap normality of 1/18.9, or .053 N. The time of degumming increases for all concentrations above or below a normality of .053 N. For conditions employed in laboratory tests[60] the critical concentration was found to be 0.028 N.

Mixtures of Soap and Alkalies

It is common practise to employ mixtures of soaps and alkalies for boiling-off. Experiments were conducted with mixtures of soaps with various alkalies and in various concentrations. In Table V summarized results are recorded. Degumming coefficients of soap-alkali mixtures were also calculated assuming that the coefficient is an additive property; soap and alkali each contributing its normal value multiplied by its equivalent fraction present. For example, in Run III with a .021 N soap solution, A_o for soap was .001125 and for Na_2CO_3, .000508, making a total initial A_o of 0.001633 corresponding to an equivalent fraction of 0.69 for soap and .31 for Na_2CO_3. Multiplying these fractions by their respective coefficients, 115 corresponding to .021 N soap, and 122 for Na_2CO_3, a value of 117 is obtained, which agrees with the experimental value. On the average the experimental coefficients for the alkali-soap mixtures were 6% lower than the calculated values.

Additional boil-off tests were made using 2.0 pounds of soap and 0.2 pound of alkali to 10 pounds of stock in the usual 200 pounds of water at 200° F. The experimental values of k with different alkalies were

Run	Alkali Used with 2 lbs. of Soap	k
54	Sodium carbonate	97
55	Sodium sesquicarbonate	84
56	Tri-sodium phosphate	104

Effect of Yarn Size

It is common experience that more time is required to boil-off heavy, service-weight hosiery than the light chiffons. M. J. Sterba[44a] determined the degumming coefficients under the same conditions as for the standard

tests, using hosiery of 4-, 7- and 10-thread silk yarns separately. The results are summarized as follows:

Run	Threads	Denierage	k
A	4	56	200
B	7	98	130
C	10	100	98

When these results are plotted on log paper a straight line results (Fig. 4). From the slope and intercept of this line the effect of yarn size upon the degumming coefficient can be expressed by the equation:

$$k = \frac{408}{D^{3/4}}$$

where D = denierage. The degumming coefficient, therefore, varies inversely with the 3/4-power of the yarn denierage, or inversely with the 1.5-

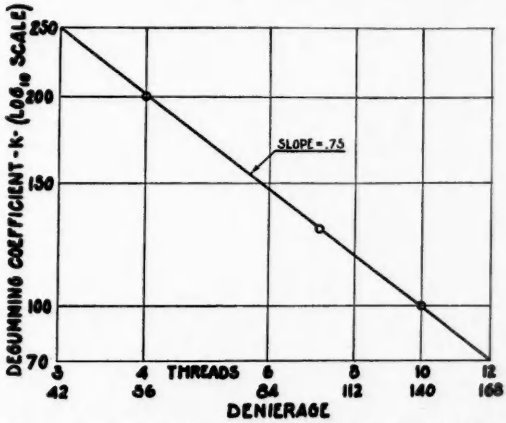

FIG. 4. Effect of yarn size upon degumming coefficient. (Data by Sterba.)

power of yarn diameter. This indicates that diffusion is an important factor in degumming; that the degumming reagents must be brought up to the yarn surface by diffusion or agitation. If the yarn were a compact solid the effect of diffusion would vary inversely with the denierage, or inversely with the square of the yarn diameter, but because of the open structure of yarns diameter is less effective in controlling the rate of boiling-off than for a compact fused structure.

Effect of Agitation

Inasmuch as yarn size is an important factor in degumming silk it would also follow that the degree of agitation is an important factor. Agitation is accomplished in boiling-off hosiery by the action of rotating and reciprocating drums. Actual boiling of the bath also affects a vigorous

agitation of the stock as the steam escapes through the fabric. Results show that when the bath is in motion the degumming coefficient is 3.5 times as great as when the goods are stationary.

Effect of Size of Boil-off Drum

Since practical boil-off runs are usually conducted upon hosiery loads of 100 pounds or more, instead of 10 pounds as used in these tests, comparative tests were made on a large-size machine with results summarized as follows:

Run	Load	Water	R.P.M.	Reversals P.M.	k
27	475	8100	3.0	2.4	74
28	10	200	4.8	2	81

The degumming coefficient was only 9% less on the large machine than on the small one, even though the weight of stockings in the large machine was nearly 50 times greater. This difference is perhaps due to the slower speed of the large machine rather than to its greater size, and is in agreement with results reported in the previous paragraph.

Effect of Size of Load

One other variable in boiling-off hosiery is of practical interest, namely the ratio of water to stock. Overcrowding the machine is known to produce undue friction and chafing and results in uneven degumming; on the other hand a high ratio of water to stock reduces correspondingly the capacity of the boil-off machine. Experimental results show that with low ratios the degumming coefficient decreases, due to diminished circulation of solution through the stock and to greater depletion of reagents. However, strange to relate, low coefficients are obtained again when a very high water ratio is used. Possibly with light loads the goods have an opportunity to float with actually less agitation. Highest values are obtained with a water ratio of about 20 to 1; either greater or lower values reduce the degumming coefficient, perhaps in each case due to reduced agitation. The experimental evidence on this point is insufficient to establish the best loading.

Effect of pH

In general the rate of boil-off increases with an increase in pH of the bath but the relation is irregular and different for each reagent. The degumming coefficients themselves are not dependent upon pH by any simple relation, nor does the value of pH enter into the fundamental degumming equation. Measurements of pH serve as an excellent means of control, but these values are by no means a direct measure of the rate of boiling-off.

Effect of Soaking Emulsion

It has already been pointed out that the nature of emulsion used in soaking raw silk affects the ease of boiling-off. In comparing two extreme types of soaking emulsions, one with a light soaking using a soluble sulphonated oil and the other with a heavy soaking using soap and fixed oils,

it was found that in the first case all the soaking oils are removed almost as soon as the goods enter the boil-off drum, whereas in the second case part of the reagent is retained by the sericin and is removed slowly along with the sericin. When compared on the basis of equal size yarns the degumming coefficient of the first yarn is 1.3 times as great as for the yarns soaked in the heavy emulsion. When yarns are heavily soaked with certain soap-oil emulsions the yarn becomes stiff and results in distorted knitting; the sericin is more difficult to remove because of such soaking.

Summary of Degumming Coefficients

The following values of degumming coefficients apply to 70 denier silk hosiery boiled-off at 200° F. in a reciprocating drum with a water ratio of 20 to 1:

TABLE V

Summary of Degumming Coefficient, k

Degumming Coefficients		Soaked with a soap-oil emulsion	Soaked with a soluble sulphonated oil emulsion
Water alone		c = .0070	c = .0091
Soap-Normality		k	k
.01		143	184
.02		118	152
.03		98	126
.04		81	104
.05		67	86
.06		55	71
.07		46	59
.08		38	49
.09		31	40
.10		26	33
Na_2CO_3		95	121
Sodium Silicate	SiO_2/Na_2O ratio		
M grade	1.0 (10.5% Na_2O)	136	175
B grade	1.63 (19.4% Na_2O)	128	164
S grade	2.62 (29.9% Na_2O)	79	101

As these coefficients apply to 70 denier silk at 200° F., they should be multiplied by the following factors for different temperatures and different sizes of yarn, the same factors applying also to coefficient c:

TABLE VI

Correction Factors for Temperature and Denierage

Correction factors for temperature		Correction factors for yarn size	
		Denierage	
212° F.	1.87	42 (3 thread)	1.89
210	1.74	56 (4 ")	1.53
205	1.29	70 (5 ")	1.29
200	1.00	84 (6 ")	1.11
195	0.835	98 (7 ")	1.00
190	0.62	112 (8 ")	0.90
180	0.39	126 (9 ")	0.83
		140 (10 ")	0.77
		154 (11 ")	0.72

Comparison of Degumming Coefficients

For practical purposes it is customary to express alkali or soap concentration on the basis of weight in pounds rather than in equivalent weights. If the degumming coefficient is defined in terms of pounds of reagent per pound of dry, clean silk, instead of equivalent weight per pound of dry, clean silk, the following comparative results will be obtained based upon boiling-off 7-thread silk hosiery at 200° F. in a reciprocating drum:

TABLE VII

		Molecular Weight	Value of k (Equivalent Weight Basis)	Value of k_1 (Pound Basis)	Order of k_1 for Alkalies (Pound Basis)
Soap-Normality		304			
.01			184	.605	
.02			152	.500	
.03			126	.415	
.04			104	.342	
.05			86	.282	
.06			71	.233	
.07			59	.194	
.08			49	.161	
.09			40	.131	
.10			33	.108	
NaOH		40	144	3.6	1
Na_2CO_3		106	121	2.27	2
Sodium silicate	SiO_2/Na_2O ratio				
M grade (10.5% Na_2O)	1.0	62 (Na_2O)	175	0.595	5
B grade (19.4% Na_2O)	1.63		164	1.025	3
S grade (29.9% Na_2O)	2.62		101	0.975	4
(8.9% Na_2O)	3.73		61	.175	8
$Na_2PO_4 \cdot 12H_2O$		380	51	.400	6
Borax, $Na_2B_4O_7 \cdot 10H_2O$		381	28	.147	9
$NaHCO_3$		84	25	.298	7

On the basis of equal weight in pounds it will be observed that caustic soda is the most active, as is well known, followed by sodium carbonate and the sodium silicates. Soap covers the same range as the milder alkalies, trisodium phosphate, borax and sodium bicarbonate, but in dilute solution is more effective than borax or bicarbonate.

Time for Boiling-off Silk Hosiery

The time required for boiling-off silk hosiery can be readily calculated from Equation (1) and Tables V and VI of degumming coefficients. The time will in every instance depend upon all the variables which influence these coefficients as well as the concentration of reagents employed, the percentage removal desired and the percentage silk in the stocking. An illustration will be given where boiling-off is conducted in a reciprocating drum at 200° F., upon a 7-thread silk hosiery (all silk), for a loading of 5 pounds of stock (in the gum, conditioned weight) to 100 pounds of water and where a 99% removal of sericin is desired. A schedule is desired for boiling-off with various concentrations of soap and also of sodium carbonate. It is customary to express the concentration of reagents on the basis of weight in pounds per 100 pounds of fabric instead of the units employed in the fundamental equation.

On the basis of 100 pounds of thrown silk, the moisture content is 11%, boil-off content 25%, and sericin content 19.5% (all values being given on the usual dry basis). On the basis of dry, clean silk this results in

Boil-off content	33.5%
Sericin content	26.0%
Soaking reagents	7.5%
Moisture	14.7%
Silk	100.0%

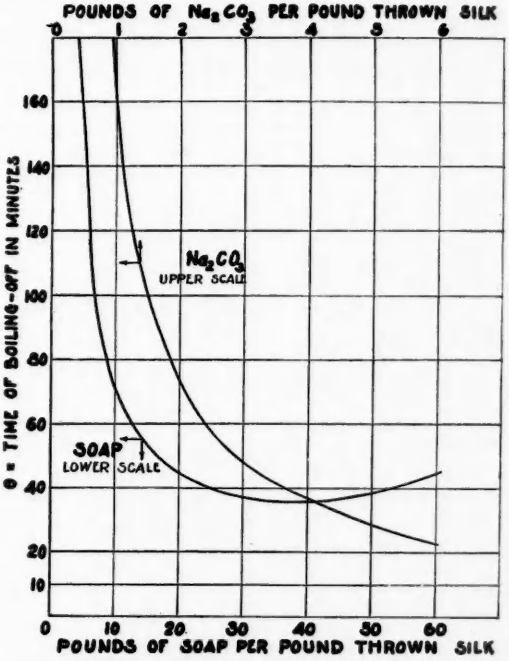

FIG. 5. Effect of soap and of sodium carbonate concentrations upon time of boiling-off silk hosiery. (7-thread; all-silk; 200° F.; water ratio 20 to 1.)

In 100 pounds of silk as received there are, therefore,

67.5	pounds	dry, clean silk
17.55	"	sericin
5.05	"	soaking reagents
9.90	"	moisture
100.0	"	

The soaking emulsion is assumed to correspond to the A type.

A boil-off time schedule will be calculated for an olive oil soap (10.2% Na_2O) varying from 5 to 60 pounds per 100 pounds of thrown silk (conditioned weight) and for sodium carbonate (58.5% Na_2O) varying from 1 to 6 pounds per 100 pounds of thrown silk.

Upon integrating Equation (1) and solving for time there results the following

$$\theta = \frac{2.3 \log_{10} \frac{S_0\left[c + k\left(a + \frac{S}{B}\right)\right]}{S\left[c + k\left(a + \frac{S_0}{B}\right)\right]}}{c + ak} \qquad (14)$$

For the conditions mentioned $c = .0091$, $S_0 = .26$, $S = .0026$, $B = 1600$, $a = A_0 - .000162$.

Substituting these values into Equation (14) the results shown graphically in Fig. 5 are obtained.

It will be observed that the minimum time of boiling-off occurs when 32 pounds of soap are used per 100 pounds of thrown silk in a bath of 2,000 pounds of water; this corresponds to a soap normality of 0.053 N, which is in agreement with the concentration reported previously. This high concentration of soap is not recommended but the results show that it is futile to exceed this normality. Procter and Gamble [32] reported a critical soap concentration at 37½% weight of silk but did not state the normality or water ratio employed. The most economical soap concentration to employ is considerably less than 0.053 N and can be determined from the time schedule together with cost data on soap, labor, machinery and stock.

Criticisms

The method employed on these large-scale tests for obtaining degumming coefficients seems more reliable than that of sampling the stock, since more uniform and more representative samples are obtained. Furthermore, this method avoids the uncertainty involved in mechanical removal of sericin by the rinsing methods previously employed. The present method can be greatly improved by providing thermostatic control of the boil-off bath and providing some means of maintaining constant weight by addition of water. By mounting the experimental drum on a platform scale the proper addition of water to maintain constancy of weight would be simple. Under the conditions employed in these tests an accuracy in values of k to within less than 10% cannot be expected.

Conclusions

1. A fundamental equation has been built up formulating the mechanism of boiling-off silk hosiery.

2. Degumming coefficients have been experimentally determined and numerically related to all the variables of operation, such as temperature, nature and concentration of reagents, mixture of reagents, loading, degree of agitation, yarn size, composition of soaking reagents, and size of drum.

3. The anomalous behaviour of soap in degumming has been shown and explained. It has been shown that increasing the soap concentration above a normality of 0.053 N actually increases the time of boiling-off.

Acknowledgments

This report is based upon about 80 plant-tests employing stocking loads of 10 pounds each, and in some cases up to 500 pounds, and involving in all about 1000 dozen pairs of stockings for 10-pound tests alone.

Much of the experimental work reported in this paper was performed at the Milwaukee plant of the Holeproof Hosiery Company under a co-operative project undertaken by the Holeproof Hosiery Company of Milwaukee and the National Oil Products Company of Harrison, N. J. Credit is acknowledged to these two companies for their generosity in releasing the theoretical phases of this investigation for publication.

Editor's Note. Detailed experimental data not published may be obtained, if desired, by addressing the author at United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J.

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Abstracts

This section is compiled under the direction of the Committee on Abstracts and Bibliography: Prof. E. R. Schwarz, Chairman, Dr. W. E. Emley, Prof. Louis A. Olney and M. W. Weiss.

I. Fibres (Synthetic and Natural) and Fibre Analysis

Cellulose: Constitution of. W. N. Haworth. *J. Soc. Dyers Col., Jubilee Issue* 1884–1934, P. 16–23; *Chem. Abs.*, 1934, V. 28, Col. 6313. (W)

Cellulose Molecules: Structure and Size of. Alf af Ekenstam. *Svensk Kem. Tids.*, 1934, V. 46, P. 157–67.

Résumé of a lecture with tables of viscosity data of cellulose solns. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 6999.) (W)

Cellulose, Mercerized Cellulose and Cellulose Hydrate. R. Klaus. *Kunstseide*, 1934, V. 16, P. 318–22.

A review and discussion of the differences shown by these three types of cellulose. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7000.) (W)

Cellulosic Compounds: Structure of. New Results Obtained by X-rays and the Diffraction of Electrons. J. J. Trillat. *Chim. & Ind.*, April, 1934, P. 175–85.

A review of recent work done on the use of X-rays and of diffraction of electrons in the study of the structure of cellulose and its derivs. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5659.) (W)

Cinematographic Swelling Analysis. K. Hess. *Papier-Fabr.*, 1934, V. 32, P. 61–7.

The swelling of cotton and wool fibres and starch granules is studied with the aid of a cinematographic film, some pictures from which are reproduced. When cotton swells in cuprammonium oxide soln., the soln. passes through the outer walls of the fibre, which act as a semi-permeable membrane, causing dispersion of the structure within the fibre. A strong flow of particles in the direction of the axis of the fibre was observed, the particles themselves showing vigorous Brownian movement. The outer walls finally burst and a very rapid outflow of liquid from the fibre takes place, an indication that the system is under pressure. Starch granules show the same behavior when swelling in H_2O. The particles of the inner suspension, which also show vigorous Brownian movement, become visible only with the addn. of EtOH, MeOH, dioxane, Et_2O, etc. It is indicated that the suspension ejected when the outer skin of the granule is burst has its own inner structure with elastic properties. Similarly, the individual scales

split off from the surface of wool when swollen show Brownian movement within. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 6360.) (W)

COTTON OR WOOD CELLULOSE? M. Steude. *Mitt. Lab. Peter Temming A.–G. Glückstadt (Holstein)*, 1933, 20 pp.; *Chem. Zentr.*, 1933, V. II, P. 804.

Comparative analyses and spinning expts. with Temming linters and with Canadian and Norwegian wood celluloses are described. The linters are differentiated from the wood cellulose by their higher *a*-cellulose content (98.5 against 88.5%), lower ash content, greater whiteness, and somewhat lower viscosity, as detd. according to Ost. They give off no colored hemicellulose in the mercerizing liquor; the yield with the linters is about 10% higher than with wood cellulose. The linter viscose can be easily spun; because of its light color it requires no bleach. The hardness and dilation values are somewhat higher than those of wood cellulose. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5977.) (W)

DEGUMMING OF SILK: INFLUENCE OF ALKALI UPON THE. VII. ANALYTICAL EXAMINATION OF THE DEGUMMED SILK. Imakichi Toyoda. *J. Soc. Chem. Ind. Japan* 37, Suppl. binding 1934, P. 292–4; cf. *Chem. Abs.*, 1934, V. 28, Col. 4912.

Easily sol. and destructive sericin ppts. almost completely in 30–60 min. during the degumming of silk. In practice, however, degumming must be carried out for at least 2–3 hrs. to remove any excess of sericin and an intermediate product which is neither sericin nor fibroin. It must be kept in mind not to have the silk fibre attacked by a too rigorous treatment, as degumming with soap may destroy 20–30% of the fibre, possibly by decomposition of the surface of the fibroin. The proper concn. of alkali therefore is of great importance. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5991.) (W)

FIBRES AND THEIR SOLUTIONS: RELATIONS BETWEEN THE INTIMATE STRUCTURE AND MECHANICAL PROPERTIES OF. R. Michel-Jaffard. *Chim. & Ind.*, April, 1934, P. 768–83.

A general discussion and explanation of the present status of the question, from which it is concluded that the mech. properties of cellulosic fibres and their solns. seem to be governed by the following factors: (1) the elongated form of the mols. which is responsible for the relation between the viscosity and concn. of their solns.; (2) the mech. properties of the cryst. particles, formed by their assemblage, which follows Maxwell's law; (3) plastic heterogeneity which produces hysteresis; (4) organization, either mech. or biol., of the fibres by orientation of the cryst. elements without change in the network, resulting in increase in their strength and decrease in their plasticity; (5) biol. organization into fibrils and layers, varying in permeability and probably also in their chem. constitution, which gives natural fibres their characteristic properties. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5979.) (W)

II. YARNS AND FABRICS

MOIST-AIR DRYING OF WARPS IN SIZING. Joseph Hibbert & Co., Ltd. *Tex. Mfr.*, 1934, V. 60, P. 278.

An illustrated description of the Hibbert dryer for sized warps. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7023.) (W)

RAYON: SIZING OF. (German.) Karl Walter. *Die Kunstseide*, May, 1934, P. 157–161.

A brief article giving several illustrations of finishes on rayon material and one or two diagrammatic sketches of types of machines used for applying the starch. In each case a constant-temperature size kettle is provided by means of a double water-jacketed construction. The location of press rolls and guarding rolls is also indicated, and this article forms one of a series running through 1934 concerned with the practice of rayon sizing. Several photographic illustrations of tentering and of slashing equipment on a large scale for piece goods are given with good detail. (S)

RAYON SIZE. H. Geier. *Kunstseide*, 1934, V. 16, P. 190–2; *Chem. Abs.*, 1933, V. 27, P. 2818.

A comparison of tensile strengths and elongations of rayons sized with glue, glue and glycerol, gelatin, gelatin and Turkey-red oil, linseed oil and Vinarol shows that the last two are superior. Films of Vinarol are about 10 times as flexible as those of linseed oil. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7027.) (W)

RAYON YARN: NOTES ON THE SIZING OF. (German.) "W. K." *Die Kunstseide*, 1934, V. 16, No. 9, P. 306–307.

A very short article discusses the importance for satisfactory sizing of rayon yarns in order to have them weave or knit without difficulty. The author notes several important points which must be taken into consideration in order to avoid damage. (S)

RAYONS: USE OF DRYING OILS FOR THE SKEIN-SIZING OF. H. Tatu. *Russa*, 1934, V. 9, P. 423–9, 494–7.

A description and discussion of the four main types of processes for the skein-sizing of rayon by means of drying oils. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5990.) (W)

SIZING MATERIALS: TESTING FOR PRESENCE OF GLUE ON GELATIN IN. Albert H. Grimshaw. *Rayon & Mell. Tex. Mo.*, 1934, V. 15, P. 17.

Millon's reagent is used to detect gelatin and glue in sizing materials and to det. the penetration of such sizes into yarns free from animal (protein) fibres. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 6318.) (W)

SIZING RAYON WITH LINSEED OIL. Harry Schreiterer. *Monatsh. Seide Kunstseide*, 1934, V. 39, P. 376–80.

S. reports the results of sizing expts. on rayon involving the use of "true" soaps with and without fat solvents, some fat-dissolving soaps which are ready for use, and some of the newer "synthetic" washing agents. Seventeen different products or combinations of materials were employed. The soap basis consisted of soap, soap-sulfonated oil and a synthetic washing agent. The fat solvents were a water-sol. fat solvent, methylhexalin, xylene, perchloro-ethylene, turpentine, CCl_4 and trichloro-ethylene. Microscopic tests are included and three photomicrographs show the action of good and poor sizing agents. The expts. showed that the use of "true" soaps is of great importance in washing linseed sizes. "True" soaps cannot be displaced in this process by synthetic washing

agents or sulfonated oils. The synthetic washing agents and sulfonated oils should only be used when working with hard water; they should never be employed as an equiv. "substitute" for soap. The fat solvent plays only a minor role. Although the use of true soap without fat solvent will remove sizes it is preferable to employ fat-dissolving soap as the latter is capable of removing at the same time both sizes and any dirt on the raw material. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7026.) (W)

SILK: SPECIFIC GRAVITY, DIAMETER, STRENGTH, COHESION, ETC. Lucia M. H. Lowry, Charles D. Lowry, Jr., and John R. Miner. *J. Chem. Education*, 1934, V. 11, P. 558–64. (W)

SIZING OF RAYON. Karl Walter. *Kunstseide*, 1934, V. 16, P. 157–61.

Discussion of the disadvantages of starch and linseed oil sizes and description of the use of rayon sizes known as "Silkovan" and "Rayonal." (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7026.) (W)

SIZING OF CUPRAMMONIUM RAYON. Werner Schepmann. *Monatsh. Seide Kunstseide*, 1934, V. 39, P. 330–7.

A review of the present methods of sizing cuprammonium rayon and tests for detg. the quality of sizing. S. includes a no. of practical formulas, such as a formula for paraffin sizing and formulas for soap baths, etc. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7026.) (W)

SIZING RAYON SKEINS: SOME TROUBLES IN. A. Brugère. *Rev. gen. mat. color*, 1933, V. 37, P. 472–5.

Discussion is confined to boiled linseed oil as a sizing material, enumerating some five factors. (1) Some deteriorated cloth made with a new method light colored oil, showing a green copper coloration, led to finding HCl, which caused the weakening, formed from the effect of moisture on BzCl found in the oil. (2) The drier must be in full combination with the oil as a soap. (3) The silk should be dry, full wetting allowed, followed by drying below 60° or spotting and yellowing from resinification will result. Average sizing per operation is 4–5%. (4) Care should be taken to prevent fires in cloth not yet freed from greasy oil. (5) Fibres should be well shaken from superficial oil to prevent sticking together and solid pellicule formation. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5990.) (W)

SLASHING: HOW MUCH STRETCH IN RAYON? H. R. Mauersberger. *Rayon and Mell. Tex. Mo.*, 1934, V. 15, No. 11, P. 547–549.

An article published as a result of the warp sizing conference of the U. S. Institute in New York City, May, 1934. The author discusses the objects of warp sizing, which he states are the stretch factor, the amount of stretch, and the recovery of stretch. Tabulated data is available together with charts indicating the nature of the stretch occurring in slashing for both viscose and acetate yarns.

It is concluded that sizers should endeavor to employ stretches of not over 4 to 5% for viscose rayon yarns, and not over 2 to 3% for acetate yarns, and that these stretches should only be increased if operating conditions absolutely demand it. (S)

SOAP SOLUTIONS USED IN DESIZING. J. Rolland. *Chim. & Ind.*, April, 1934, P. 851–3.

Chem. analyses of solid soaps used in desizing does not always furnish sufficient information regarding their behavior in use, and should be complemented by detn. of the pH and detergent power of the soln. For fibres which are sensitive to alkalies and absorb fatty acids, the Na_2CO_3 and glycerol contents of the soap also are important. Knowledge of the pH permits readjusting spent solns. with NaOH for further use, the detergent value being restored almost to its original use. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5991.) (W)

VISCOSITY OF SIZE: VARIATIONS IN THE. G. Wolff. *Textil-Forsch.*, 1934, V. 16, P. 65–8; *Chim. & Ind.*, V. 32, P. 416.

A brief discussion of the effects of the variations in the viscosity of textile sizes, with a description of the method of detg. it. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7023.) (W)

WATERPROOFING FABRICS BY MEANS OF RUBBER. Gabriel Simonin. *Tiba*, 1934, V. 12, P. 345–9, 421–7, 503–9.

A detailed description of the manufacture of rubberized waterproof fabrics and of its control. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5992.) (W)

WOOL: RESISTANCE TO TEARING AND TENSILE STRENGTH OF—TREATED WITH CHEMICAL REAGENTS. H. Markert. *Textil-Forsch.*, 1934, V. 16, P. 32–5; *Chim. & Ind.*, V. 32, P. 415; *Chem. Abs.*, 1934, V. 28, Col. 1867, 7027. (W)

WOOL HAIRS: CHANGES UNDERGONE BY—DURING THE WHOLE MANUFACTURING PROCESS UP TO THE FINISHED DYED FABRIC. P. Krais, H. Markert and O. Viertel. *Forschungsh. deut. Forsch.-Inst. Textilind. Dresden*, 1933, V. 14, 73 pp.; *Chem. Zentr.*, 1933, V. II, P. 2211–12; *Chem. Abs.*, 1934, V. 28, Col. 6317.) (W)

WOOL AND MILDEW. F. C. Pratt. *Rayon and Mell. Tex. Mo.*, August, 1934, P. 40–41.

An abstract of a paper which appeared originally in the *Tex. Recdr.* Damage to textile materials by mold or fungus and that caused by bacteria are discussed. It is estimated that 45% of newly clipped wool is damaged in the fibre. Microscopic examination of the affected material shows that progressive tendering has taken place. The scales are first affected and this is followed by isolation of the spindle-shaped cortical cells. It is stated by one authority that fibres with apparently intact outer casings sometimes show damage after treatment with alkali which must have existed internally in the form of split and longitudinal fissures. It is further noted that Pauly's test involving diazo-benzene-sulphonic acid is of value in showing the damage by means of a yellow to deep red coloration which varies according to the extent of the damage done. It is further noted that the idea that processing material in an acid condition involves freedom from trouble by mildew growth is incorrect. In fact a slightly acid substratum has been found to encourage it in certain cases. Emphasis, according to the author, should be placed on attempt to prevent formation of either fungus or bacterial growth, rather than to attempt to remedy the trouble. He notes that at no stage in the production of textile fabrics may the com-

ponent fibres be said to be immune from attack. Several formulas for treatment of materials are given. (S)

III. Chemical and Other Processing (Not Otherwise Classified)

Absorption Spectra and Luminescence in Concentrated Solutions of Dyes. V. L. Levshin. *Compt. rend. acad. sci. U. S. S. R.*, 1934, V. 2, P. 405–8 (in French 408–10); *Chem. Abs.*, 1934, V. 28, Col. 5759. (W)

Alkaline Treatment of Cotton at Low Temperature. Sho Sengoku. *Repts. Imp. Ind. Research Inst., Osaka, Japan*, 1934, V. 15, No. 4, P. 1–2.

S. studied the effect of mercerization of cotton at low temp. (— 20°) on strength, color, feel, I absorption, etc. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 6571.) (W)

Aniline Black: Composition, Reactions and Classification. Justin-Mueller. *Tiba*, 1934, V. 12, P. 659–65; cf. *Chem. Abs.*, 1934, V. 28, Col. 6569.

A review with 27 references. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7538.) (W)

Aniline Black Dyeing. H. Franke. *Kunstseide*, 1934, V. 16, P. 156–7.

A black color without greenish cast can be produced on cloth by impregnating and printing with the regular soln., drying, heating at 110–180° for 5–40 sec., then steaming for 15–60 sec. A saving in aniline results by adding small amts. of aminoazobenzene, aminoazotoluene, diaminobenzene or azobenzene. With weighted silk to be dyed black, the customary alk. hematin bath should be replaced with a bath contg. hematin and boiled chrysalises. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7017.) (W)

Anthraquinoneazo Compounds. VIII. Some Monoazo Dyes from H-acid. IX. Some Primary Disazo Dyes from H-acid. T. Maki and O. Suzuki. *J. Soc. Chem. Ind., Japan* 37, Suppl. binding, 1934, P. 227–33; cf. *Chem. Abs.*, 1933, V. 27, P. 3614; 1934, V. 28, Col. 5433–4. (W)

Artificial Resin Industry in the Field of Synthetic Chemistry. K. Haupt. *Kunststoffe*, July, 1934, P. 163–4.

A short article includes a flow sheet showing the production of chloroprene, phenol, vinyl, and carbamide resins from water, carbon, and air as starting materials. (Copied complete from *Eastman Kodak Abs. Bull.*, Oct., 1934, P. 367.) (S)

Azoic Colors. A. E. Everest and J. A. Wallwork. *J. Soc. Dyers Col.*, 1934, V. 50, P. 37–41.

A paper dealing primarily with the application of azo colors to wool. The properties of these dyes are compared with those of other colors in use on wool and unions, and consideration is given to their adaptability and methods of obtaining certain effects. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 6315.) (W)

BIANCAL—A NEW ORGANIC COMPOUND FOR TEXTILES. W. Gutman. *J. Soc. Dyers Col.*, 1933, V. 49, P. 373–7; *Chem. Abs.*, 1934, V. 28, Col. 6571. (W)

BLEACHING FOR LIGHT SHADES. Hans Engel. *Z. ges. Textil-Ind.*, 1934, V. 37, P. 329–30.

The addn. of $KMnO_4$ to a mercerizing bath followed by a sour with $NaHSO_3$ is applicable to hosiery, cotton gloves, etc. Leukotex PS used in the rinse after mercerizing gives a similar effect and adds softness. Other products such as Blancit I, Burmol, ZS paste, hyposulfite and perborate are also mentioned. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7030.) (W)

BLEACHING OF LINEN YARN WITH CHLORINE LIQUORS. R. Kling. *Z. ges. Textil-Ind.*, 1934, V. 37, P. 325–7; *Chem. Abs.*, 1934, V. 28, Col. 7029. (W)

BLEACHING OF MIXED TEXTILES OF COTTON AND VISCOSE. L. Lomanovich and V. Marker. *Iskusstvennoe Volokno* (*Artificial Fibre*), 1934, V. 5, No. 4, P. 39–41; *Chem. Abs.*, 1934, V. 28, Col. 3591, 6318. (W)

BLEACHING OF YELLOW SILK IN THE BAST. F. Andreas and H. Korb. *Monatschr. Textil-Ind.*, 1934, V. 49, P. 160.

The method of bleaching yellow silk in the bast is based on a H_2O_2 bleach followed by a blankite bath. Full directions are given. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 7030.) (W)

BLEACHING WITH HYDROGEN PEROXIDE IN ACID BATHS. A. Molnar. *Monatschr. Textil-Ind.*, 1934, V. 49, P. 18; *Chem. Abs.*, 1934, V. 28, Col. 7029. (W)

CALICO PRINTING: PROGRESS IN. J. B. Fothergill. *J. Soc. Dyers Col., Jubilee Issue* 1884–1934, P. 115–26; *Chem. Abs.*, 1934, V. 28, Col. 6315. (W)

IV. RESEARCH METHODS AND APPARATUS

CHEMICAL TESTING OF WOOL. K. Augustin. *Z. ges. Textil-Ind.*, 1933, V. 36, P. 223–5; *Chem. Abs.*, 1934, V. 28, Col. 7540. (W)

COPPER IN FABRICS: ESTIMATION OF SMALL QUANTITIES OF. Gustav Durst. *Mell. Textilber.*, 1934, V. 15, P. 314–5; *Chem. Abs.*, 1934, V. 28, Col. 7544. (W)

COTTON CLASSER FINDS A VALUABLE TOOL IN THE POLARIZING MICROSCOPE. Cheslee L. Pattee. *Tex. Wld.*, V. 84, No. 11, P. 80–1; *Tex. Rsch.*, 1934, V. 5, No. 2, P. 72–4.

An article showing how the maturity of cotton may be determined by use of the polarizing microscope. The technique is not difficult nor is it time consuming and the article should be of considerable interest to all cotton mill men. The method is being adopted in plants other than that in which it originated, and the technique is an excellent example of the applications of microscopy to the every day processes in the textile mill. (S)

EVENNESS TESTER. Irving J. Saxl. *Rayon and Mell. Tex. Mo.*, 1934, Vol. 15, No. 12, P. 33–4.

A brief description of an apparatus for determining the regularity of diameter under compression of rayon yarns. It is a similar device to one

used sometime ago by E. D. Walen then of the Cotton Research Co. The device employs a shoe against which the yarn is pressed and an optical system which reflects a beam of light in the mirror attached to the shoe to a photographic strip of sensitized paper or on to a calibrated screen. (S)

HYGROMETRIC PROPERTIES OF TEXTILES AND THE CONDITIONING OF RAYONS. Etienne Burlet. *Chim. & Ind.* Spec. No., April, 1934, P. 824–32.

The equil. moisture content attained by a given sample of a textile fibre in an atm. of definite temp. and relative humidity varies with the past humidity history of the fibre, particularly with rayons. The true wt. of a sample under standard conditions may be obtained by dividing the sample into two halves, drying one half (below 60°) and moistening the other half, exposing both halves to the standard atm. (generally 18° and 65% relative humidity) for several hrs. and weighing. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 5990.) (W)

INTERPRETATION AND VALUE OF THE LOAD EXTENSION DIAGRAM. (German.) K. Diemer. *Die Kunstseide*, June, 1934, P. 182–9.

The article states that only approximate conclusion as to the behaviour of material in mechanical and technological processes can be drawn from the maximum values of tensile strength and extension at rupture. On this account more attention is continually being devoted to the shape of the load-extension curve. An apparatus for testing individual strands of rayon is illustrated. The apparatus consists of a fixed lower jaw, and an upper jaw, the vertical motion of which may be recorded by a lever system on a chart while the motion itself is brought about by means of a balanced arm damped out in an oil bath and loaded by means of a weight which is caused to travel along it by means of a screw in the approved fashion for many tensile testing machines. Several diagrams, as drawn by the machine and the accompanying interpretations, are given. The distinction between elasticity and elongation is made and a number of references to the literature and to the patents are noted. (S)

MICRO-DRAWINGS, PHOTOGRAPHS AND FILMS IN TEXTILE CHEMISTRY: USE OF. H. Reumuth. *Chem.-Ztg.*, 1934, V. 58, P. 345–7.

Examples are described, with illustrations, of the use of photomicrographs and kinematomicrographs in textile chemistry. (Copied complete from *Chem. Abs.*, 1934, V. 28, Col. 6570.) (W)

MICROSCOPICAL EXAMINATION OF THE PRODUCTS OF THE RAYON INDUSTRY. (German.) Jacques Klinger. *Die Kunstseide*, 1934, V. 16, No. 11, P. 388–91.

The author outlines the possibilities of microscopical examination of various types of rayon and artificially delustred rayons as compared with other types of materials such as wool, goat hair, linen, etc. Several photomicrographs illustrate the short article. (S)

V. ECONOMICS AND MISCELLANY

IMPORTANCE OF INTERPRETATION TO THE INDUSTRY OF FUNDAMENTAL TEXTILE RESEARCH. E. R. Schwarz. *Am. Silk and Rayon J.*, 1934, V, 53, No. 12, P. 34–5.

A paper presented at the annual meeting of the United States Institute for Textile Research in New York City. The writer attempts to stress the

importance of interpretation of the present scientific trends so that they may be utilized for practical application in the mills both as to improvement of process and time saving operation. Several examples are noted. (S)

ESSENTIALS OF SCIENTIFIC RESEARCH INTERPRETATION. Dr. Robert E. Rose. *Am. Silk and Rayon J.*, 1934, V. 53, No. 12, P. 35, 57–8.

A paper presented at the annual meeting of the United States Institute for Textile Research. Interpretation of research from the chemist's point of view is included with a discussion centering about the discovery and belated utilization of hydrogen ion concentration control. (S)

SIZING: PARTIAL BIBLIOGRAPHY OF. C. H. Clark. *Am. Dye. Rptr.*, 1934, V. 23, No. 27, P. 744–6.

This is a compilation of papers dealing with research on sizing and sizing materials for finishing fabrics and is a result of the sizing conference held by the United States Institute for Textile Research in the Spring of 1934. (S)

Book Reviews

1933 YEAR BOOK OF AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS. Howes Publishing Co., Inc., New York, N. Y. P. 474. Price, $3.00.

In addition to the annual reports of committees and sub-committees and an alphabetical list of members, as of June 1, 1934, this year book contains a revised table of American dyes and the following new features: An alphabetical list of textile chemical specialties, showing their use, their chemical names and a key to identity of manufacturers; also a bibliography on the action of acids on wool. (C)

UNION-MANAGEMENT CO-OPERATION IN THE "STRETCH OUT." Richmond C. Nyman and Elliott D. Smith. Yale University Press, New Haven, Conn. P. 210. Price, $3.00.

In 1927, the most prosperous year in the history of the Pequot Mills, Salem, Mass., a union-management co-operation plan was established. The period between then and the early part of 1929, when business and profits had slumped, is reviewed briefly by the authors, who are Yale University professors working for the Institute of Human Relations of Yale. Their book covers the period between January, 1929, and the Summer of 1933, and may be accepted as a factually accurate story of the efforts of the mill management and labor working together to solve the human problems of the so-called "stretch out." They admit "that rarely, if ever, have co-operative efforts of management and labor to serve the common good surpassed those of union-management co-operation at the Pequot Mills."

While the authors have visualized and reported fairly the human problems involved in this mill, they seem to have had little conception, and have written but briefly, of the competitive problems involved. A comprehensive and conclusive review of the subject can be written only when competitive conditions throughout the whole industry are surveyed. (C)